Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)

THE FIRST S-RAMP CONFERENCE

Sapporo, Japan; October 2-6, 2000

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S-RAMP (STEP - Results, Applications and Modeling Phase) is a five year program organized by the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP), which extends over the period 1998-2002. The three major objectives of S-RAMP are:

1. To facilitate and enable the detailed study of the STEP data base so as to increase our understanding of the physical mechanisms responsible for coupling the various regions of the Sun-Earth system.
2. To facilitate and enable the effective transfer of data and information among S-RAMP researchers and to encourage feedback among the experimental, theoretical and computer modeling communities.
3. To demonstrate the scientific findings and their societal benefits to funding agencies, the media and the general public so as to generate support for future scientific programs, cross-disciplinary studies and practical applications of knowledge of the Sun-Earth system.

The First S-RAMP Conference is held in the city of Sapporo, the capital of the Japanese Prefecture of Hokkaido. The meeting is devoted to the presentation of initial results from the follow-on to the Solar-Terrestrial Energy Program (STEP). This Sapporo Conference is the first of two major meetings planned for the S-RAMP period. The Conference takes place at Royton Sapporo (*oral sessions*), and Sapporo Media Park (*poster sessions*).

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PROGRAM BOOK: Welcome, Message from the President of SCOSTEP, Message from the S-Ramp Steering Committee and the Conveners of the First S-Ramp Conference, and Sapporo Welcomes the First S-Ramp Conference. Additionally, includes General Information, Organizers and Program Committees of Symposia/ Workshops, Time Schedule, Program, Workshops and Author Index (98 pages)

ABSTRACTS:

Tutorials: Solar-Terrestrial Physics – Past Achievements and Future Opportunities; Global Circulation of the Middle Atmosphere, and Sun-Earth Coupling and Possible Effects on Earth's Climate. Symposia: 19 Abstracts. Workshops: Space Weather Observation in Future, Satellit Anomalies, and April-May 1998/September 1999 Events (464 pages).

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The First S-RAMP Conference

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Solar-Terrestrial Environment Laboratory
Nagoya University

Radio Science Center for Space and Atmosphere
Kyoto University

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Tutorials

Symposia

Workshops

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SOLAR-TERRESTRIAL PHYSICS — PAST ACHIEVEMENTS AND FUTURE OPPORTUNITIES

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The study of solar-terrestrial physics — or what is now sometimes called Sun-Earth Connections — has a remarkable history and a most exciting future. Immense progress was made in roughly the past century with an accelerating pace of discovery, synthesis, and understanding in the past decade or so. An increasingly clear picture of the sun and its most powerful physical processes has been aided by nearly continual imaging in a broad range of wavelengths. Propagation of solar disturbances through the interplanetary medium has been measured and modeled in creative ways. Quite importantly, unprecedented armadas of near-Earth spacecraft have given us clear, global senses of how solar-produced events affect the geospace environment. The vast arrays of ground-based measuring platforms and models of all descriptions help to bring order and clarity to the Sun-Earth picture. Recognition by policy makers that near-Earth space is of crucial economic and societal importance means that future basic research — as well as applied research — in solar-terrestrial physics should be bright.

T-2

GLOBAL CIRCULATION OF THE MIDDLE ATMOSPHERE

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Recent progress in our understanding of the middle atmosphere circulation is reviewed in terms of global observations and wave dynamics. Following a brief historical review of the construction of the middle atmosphere climatology after the IGY period, such as CIRA 65,72,86 models, developments of the dynamics of planetary waves and gravity waves are discussed in detail, for both extratropical and equatorial circulations. It is stressed that the wave-mean flow interaction is the key-idea for the understanding of the observed middle atmosphere which significantly deviates from the radiative equilibrium state. Discussions are extended to the long-term variations of the middle atmosphere circulation, such as the effects of the equatorial quasi-biennial oscillation (QBO) and the solar-cycle on the extratropical circulation. Finally, it is suggested as to what is requested for the "new climatology" of the middle atmosphere on the basis of the accumulated data-set of global satellite observations in the last two decades.

T-3

SUN-EARTH COUPLING AND POSSIBLE EFFECTS ON EARTH'S CLIMATE

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The recent decades have significantly increased our knowledge about our outer environment and its dependence on solar surface conditions via different Sun-Earth coupling mechanisms. Several findings even point at a possible direct effect on climate of solar variability. During the same time interval mankind has become more and more concerned about the closest part of our environment, namely the atmosphere and in particular how its composition is changed due to the increasing amount of greenhouse gases, in particular carbon dioxide, that result from human activity.

Whereas the enhanced greenhous effect may be simulated in the large climate models, our knowledge is not yet sufficient to determine how the solar forcing can play a significant role apart from the obvious possibility that the total solar irradiance changes sufficiently much to account for the observed climate changes. Accurate observations of the total solar irradiance are not possible from ground because of the disturbing effect of variations in the atmospheric composition. Only when direct measurements from satellites became available in the 1980s, the hypothesis of a solar cycle variation in total irradiance could be tested. These measurements demonstrated that the irradiance during a solar cycle varied in phase with the sunspot cycle but the variations only amounted to 0.1% between sunspot maximum and sunspot minimum, hardly enough to have a significant effect on the global temperature.

Another possible mechanism is related to the ultraviolet part of the solar irradiance spectrum. Solar cycle variations in this spectral band are much larger than for the visible light. Attempts have been made to model the climatic effect of solar cycle variations taking into account also the modulating effect of the varying ultraviolet radiation on the lower stratospheric ozone. The model results are consistent with observations, although the observations indicate a much larger effect than predicted by the models.

But an even a more pronounced manifestation of variations in solar energy output is seen in the emission of particles and fields from the solar surface. Although the energy in the solar wind is negligible compared to the energy in the ultraviolet and visible spectral bands, the relative variations are much larger. A direct effect of the varying solar wind is seen in the fluctuations in cosmic ray flux that is measured on Earth.

One of the major uncertainties in climate models is the role of clouds. In particular there are large difficulties associated with the parameterisation of these effects in general circulation models used in climate studies.

Recent studies indicate that cloud formation may be influenced by galactic cosmic rays through ionisation changes that cause microphysical changes in the atmosphere. Hereby the initiation and growth of cloud condensation nuclei may be affected.

A change in cloud cover would indeed be an extremely effective amplifying mechanism for climate forcing because the energy needed to condense water vapour is small compared to the resulting changes in energy of solar radiation received at the Earth's surface. The correlation between the cosmic ray flux and the global cloud cover is very high and indicates a direct relationship although a detailed physical mechanism is still lacking.

S1-01

REPORT ON THE SOLAR CYCLE 23 PREDICTION PROJECT

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In September, 1996, in advance of knowledge of the end of Solar Cycle 22, an international panel of 12 scientists met in Boulder, Colorado to consider a collection of 28 predictions of the profile and amplitude of Cycle 23 solar and geomagnetic activity. This panel, sponsored by NASA's Office of Space Science, NOAA's Space Environment Center, and the respective agencies of the panel members, met again in 1997, 1998, and 1999 to review the forecasts and consider new published forecasts and accumulating information about the progress of Solar Cycle 23. The Panel never found cause to change their original forecasts of the solar cycle amplitude and timing [a smoothed sunspot number amplitude of 160 (between extremes of 130 and 190) reaching maximum near March 2000 (between extremes of June 1999 and January 2001)]. These forecasts are not yet excluded by the data. Likewise, the prediction of a geomagnetic cycle that would behave similarly to the previous cycle has not been changed. However, both the solar and geomagnetic cycles have not progressed as expected in that the profiles during the rising phase of this cycle have not been similar to the past several cycles. Instead, Cycle 23 activity has been rising much more slowly, consistent with either an average amplitude cycle (such as Cycle 20) or a irregularly-shaped cycle such as Cycle 15 (and other) cycles. This talk will review the techniques and rationale used to reach various cycle predictions, and will compare the results with the progress of Cycle 23 through September, 2000.

S1-02

MEASUREMENTS OF SPACE WEATHER FORECAST PERFORMANCE

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The need for objective measures of the performance of space weather forecasts is self-evident. For users of forecasts, these measures indicate the trust which can be put on forecasts and ultimately determine the use which is made of them. For forecasters and scientists, performance measures indicate the degree to which new data and techniques have contributed to improving the quality of forecasts. Yet the development of good performance measures has proved very difficult. Many space weather forecasts remain valuable despite 'errors' in amplitude and timing of disturbances; and this value is not reflected in conventional numerical indicators. This paper discusses these issues in the context of the current space weather services produced by IPS Radio and Space Services.

S1-03

THE POSSIBILITY OF SOLAR FLARE AND CME PREDICTION FROM PHOTOSPHERIC MAGNETIC FIELD MEASUREMENTS

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The numerical 3D MHD models for prediction of CME and flares are presented. The predictions are based on photospheric magnetic measurements which should be taken as boundary conditions for calculations in the corona. The energy storage in the current sheet in the corona is shown for following conditions: 1) The current sheet creation above an active region due to photospheric disturbances focusing in the vicinity of a neutral line. 2) Current sheet creation at emergence a new magnetic tube, and its interaction with the old magnetic field of opposite direction. It is shown the vertical current sheet creation. The energy release is occurs in the corona due to current sheet decay. Two scenario of CME development are numerically simulated: 1) A strong post flare creation because of local chromospheric evaporation. The energy is transferred from the current sheet to the photosphere by fast electrons accelerated in field-aligned currents. High β plasma flow along field lines can not be confined by the magnetic field on the top of a loop, and the plasma stream escapes from the corona. 2) Plasma upward acceleration by the $\boldsymbol{j} \times \boldsymbol{B}/c$ force in the vertical current sheet during a solar flare. The results of calculation are in agreement with observational data. For simulation explosive events in the corona the PERSVET code is developed. Plasma resistivity and thermal conductivity are taken into account.

S1-04

USE OF SOLAR IMAGES FOR PREDICTIONS OF INTERPLANETARY DISTURBANCES

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Solar wind condition is continuously monitored from the L1 point. Using the solar wind data at the L1 point, it is possible to predict geomagnetic activity accurately after approximately one hour. However, prediction of solar wind condition after more than one hour is still under consideration. We need to handle solar images quantitatively rather than qualitatively to predict solar wind condition after two or three days accurately. For an example we tried to predict solar wind speed from coronal holes using soft X-ray images taken by Yohkoh. Solar images are used just to identify existence of coronal holes now. We developed a method to predict solar wind speed near 1 AU using intensity of images. The Soft X-ray Imager (SXI) on board the NOAA/GOES satellite will be launched in fall 2000. The SXI will provide us a large amount of images. Quantitative handling of the images for space weather forecast should be needed adding to qualitative approach.

S1-05

ESTIMATION OF THE SOLAR WIND SPEED BY THE EXPANSION RATE OF THE CORONAL MAGNETIC FIELD

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Variations of the solar wind speed (SWS) cause enhancements of the interplanetary magnetic field and the number density of solar wind particle. The variation of the SWS, thus, causes magnetospheirc storms and substorms; that is, it plays an important role for the Space Weather forecasting. Synoptic maps of the SWS estimated by the computer assisted tomography (CAT) method with interplanetary scintillation observations are constructed for 1830 and 1909 Carrington rotations; that is, for the maximum and for the minimum phase of solar activity cycle, respectively. The similar synoptic maps of expansion rate (RBR) of the coronal magnetic field calculated by the so-called 'potential model' with the photospheric magnetic field are also constructed under the radial field assumption. This potential model is called RF-model after the Radial Field assumption. An individual map consists of 64,800 (180 × 360) data points of equal area. We examine relations between the SWS estimated by the CAT technique and the RBR calculated by the RF-model. Highly significant correlation is found between the SWS and the RBR during CR1909 in the solar minimum phase. A simple correlation coefficient is about −0.72; that is, high-speed winds emanate from photospheric areas corresponding to low expansion rate of the coronal magnetic field and low-speed winds emanate from photospheric areas of high expansion rate. The similar result is found between the SWS and the RBR during CR1830, though the correlation coefficient is relatively low in the solar maximum phase. These results suggest that the SWS can be estimated by the RBR and this technique can be applicable to estimate conditions of the solar wind speed for the Space Weather forecasting.

S1-06

MONITORING THE PROGRESS OF TRAVELLING SHOCKS BETWEEN THE SUN AND THE EARTH USING PARTICLE AND PLASMA SIGNATURES RECORDED ABOARD SOHO, ACE, WIND AND INTERBALL

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The NOAA/USAF Shock Time of Arrival Model (STOA), the Interplanetary Shock Propagation Model (SPM) and the USAF/EXPI/ University of Alaska's Hakamada-Akasofu-Fry Model (HAF) are routinely used in real time to predict the times of arrival of those shocks that travel outwards from the Sun to the Earth in association with heightened solar activity. In the present study, a selection of travelling shocks, the times of departure of which from the Sun are marked by the occurrence of flare associated Type II radio bursts, are monitored along their trajectories from the Sun to the Earth using particle signatures recorded by the LION instrument on SOHO and by the EPAM instrument on ACE (both of which orbit the L1 Lagrangian Point), and by the DOK-2 energetic particle detector on Interball (which describes a highly elliptical orbit around the Earth with an apogee of 2×10^5 km and a revolution period of 4 days). Characteristic jumps in V, n, B and T recorded aboard WIND by the SWE (MIT Faraday Cups) and the MFI (Magnetometer) are also used to detect the arrival times of the travelling shocks at

this latter spacecraft. The arrival at the Earth of each shock in the sample is determined by the time of a Sudden Commencement (SC). The goodness of fit of the individual shock propagation models mentioned is tested along each trajectory by comparing the predicted with the observed times of arrival of the various shock fronts identified at SOHO, ACE, WIND, Interball and the Earth. These various data provide insights into the solar and interplanetary circumstances that, in individual cases, influenced the shock propagation speed.

S1-07

A REAL-TIME HYBRID HELIOSPHERIC MODELING SYSTEM

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The Hybrid Heliospheric Modeling System (HHMS) is a Sun to Earth model suite that uses available models to forecast the geomagnetic *Ap* index from Solar observations. The HHMS model suite consists of four models. The first is a Potential Field Source Surface Model that covers the range from the photosphere to 2.5 solar radii (R_s). Second, a simple empirical model extrapolates from the "Source Surface" at 2.5 R_s to MHD parameters at 0.1 AU (21.5 R_s). The third is a 3D time dependent numerical MHD solar wind model (with it lower, inflow, grid boundary at 0.1 AU) that covers the remaining distance to Earth (at 1 AU). The MHD solar wind model provides a time series of MHD parameters at Earth to the final model which predicts the geomagnetic *Ap* index. The HHMS model suite uses two types of input. The first is solar magnetograms. Each new magnetogram that becomes available is used to update a global (synoptic) magnetic map of the sun. The sequence of magnetic maps drives the model suite and thus provides an evolving "background" state of the inner heliosphere. The second form of input is for modeling transients such as shocks and CMEs. These transients are superimposed on the quasi-steady background at the input to the 3D MHD code. The system is modular; it is expected that newer models will be substituted when sufficient improvement or benefit is demonstrated. Initial test results (and possibly real-time results) will be described.

S1-08

THE USE OF ARTIFICIAL NEURAL NETWORKS AS FORECASTING DRIVERS FOR THE MAGNETOSPHERIC SPECIFICATION MODEL AND THE ENERGETIC ELECTRON MAGNETOSPHERIC SPECIFICATION MODEL (EEMSM)

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Any magnetospheric model driven solely by solar wind parameters has the intrinsic advantage that upstream solar wind values provide a forecast period equal to the solar wind transit time. The Magnetospheric Specification Model (MSM), which provides space weather-relevant electron, proton and oxygen ion fluxes up to 100 keV, requires Kp as a mandatory input parameter. Dst, the auroral equatorial boundary at midnight (MEB), and the polar cap potential (PCP) are optional but desirable MSM inputs. The Magnetospheric Specification and Forecast Model (MSFM) uses neural networks to forecast Dst, MEB and PCP over a one hour period. However, reliance on Kp limits the model to real-time minus the acquisition time for the Air Force proxy Kp derived from ground observatories. In practice, this acquisition time is about one hour which is just offset by the one-hour neural network forecast. One way to obtain a true forecast is to develop a neural network forecast for Kp that depends on solar wind parameters. This has been done. This Kp neural network can be used as a stand-alone proxy forecast for Kp, or it can be used to drive the MSFMproviding a true forecast of magnetospheric charged particles. The forecast is further extended when upstream solar wind data are used as input. Recently we have under development a version of the MSFM that specifies the flux of relativistic electrons (EEMSM). One problem associated with building such a model is the requirement for input specification (or forecast) of MeV electron fluxes on the outer boundary at all local times. Geostationary satellites can provide fluxes at a few local times behind real-time. Once again neural networks appear to offer a solution. They can be trained to provide a forecast of the energetic electrons at the geostationary orbit. We will demonstrate these various neural networks.

S1-09

DIURNAL AND SEASONAL EFFECTS OBSERVED IN THE *Dst* INDEX

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Many indices of magnetic activity exhibit maxima in activity near the equinoxes. The standard explanation for these maxima is the Russell-McPherron effect where the IMF has a large component along the earth's dipole axis at certain universal times and certain seasons. Magnetic storms are more probable and larger at the equinoxes so one should be able to observe the R-M effect in the Dst index of storm activity. A recent study by *Cliver et al.* [2000] demonstrates that the expected R-M effects are not obvious in this index. We have investigated this relation using a different technique from *Cliver et al.* and obtain a somewhat different conclusion. We utilize a local linear prediction filter technique that determines the coefficients of a first order differential equation describing Dst (the Burton equation). In our case the coefficients are found to be functions of UT and season. The coefficient that describes the coupling of the solar wind electric field to ring current injection is modulated by the tilt angle of the dipole in such a way that the maximum injection efficiency occurs when the dipole is exactly orthogonal to the earth-Sun line. The R-M effect is occurring, but the reconnection efficiency is modulated by the tilt of the dipole. It appears that reconnection is less efficient when the solar wind strikes the magnetosphere away from the magnetic equatorial plane.

S1-10

NONLINEAR DYNAMICS: A NEW APPROACH IN HIGH-LATITUDE IONOSPHERIC ELECTRODYNAMICS MODELING

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Nonlinear dynamical models have proved useful in predictions of geomagnetic disturbance amplitudes (indices). The spatial extension of these models, reproduces the maximum amplitude and the large-scale features of the surface magnetic field at high latitudes. These spatiotemporal models are used to drive the KRM current inversion algorithm with an auroral conductance model [*Ahn et al.*, *JGR*, 1998]. The field model has been derived from the response of four magnetometer arrays to the solar wind electric field or the polar cap index for several levels of activity and all local times. The KRM current inversion algorithm is applied together with the model ionospheric conductance to obtain the currents, electric potential, and Joule heat. We report the prediction capability of the model for several intervals of interplanetary activity that range from a northward IMF interval to a CME-induced disturbance.
URL: http://lepgst.gsfc.nasa.gov/nrt_predictions.html

S1-11

SPECIFICATION AND FORECAST OF ENERGETIC MAGNETOSPHERIC ELECTRONS AND IONS

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Prompt and accurate assessments of enhancements in near-Earth energetic particles are crucial to understanding causes of space system operational problems. For this purpose, it is necessary to know the present (and recent past) space radiation environment. Ideally, this means that one should be able to specify the temporal behavior of electrons and ions at all relevant altitudes, latitudes, and local times over the entire energy range of interest to space system operators. Through the use of data from a variety of scientific and operational spacecraft, it has been possible in recent times to develop "dynamic" radiation belt models. Our present work in this regard uses a type of data assimilation technique. With such modeling, we are generally able to achieve high accuracies ($\gtrsim 75$) of energetic electron flux specification throughout the outer electron radiation belt ($2 \lesssim L \lesssim 7$) . We are also able to forecast electron fluxes accurately for some $24 - 36$ hours based upon an analog modeling technique. Future work employing these methods should allow accurate, reliable specification for magnetospheric ion populations as well.

S1-12

FORECASTING SOLAR ACTIVITY WITH AI

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The driver of space weather is the solar activity. The variability of solar activity has been described as a non-linear chaotic dynamic system. Artificial neural networks (ANNs) can model such a system. ANNs derive their power from the collective processing of artificial neurons and the main advantage of ANNs is that they can learn and adapt to a changing environment. Within knowledge-based neurocomputing (KBN), *i.e.* methods based on classical Artificial Intelligence (AI) and ANNs, it's possible to both describe the use of and the representation of the knowledge within the neurocomputing application. With KBNs therefore both an understandable model and forecasts of solar activity can be obtained. A new attempt to forecast the solar activity using SOHO/MDI solar magnetic field data and various AI methods is discussed. The purpose of this new attempt is to be able to forecast episodic events and the occurrence of coronal mass ejections.

S1-13

PREDICTING MAGNETOSPHERIC ACTIVITY WITH A LOW-DIMENSIONAL DYNAMICAL MODEL

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WINDMI is six-dimensional nonlinear dynamical model for the principal energy components of the solar wind driven coupled Magnetosphere-Ionosphere system. The model is based on truncated descriptions of the collisionless microscopic energy transfer processes occurring in the quasineutral layer, and includes a thermal flux limit neglected in the Magnetohydrodynamic (MHD) closure of the moment equations. The system is both Kirchhoffian and Hamiltonian, ensuring that the power input from the solar wind is divided into physically realizable energy sub-components. Using particle simulations to calculate the model parameters produces good agreement with observations, but the technique is difficult to implement as a prediction method because of the heavy numerical demands of matching the particle simulations to observed parameters. A database of simulations that spans the relevant parameter space is being developed to help automate the process. A database of optimal parameter values for the model has also been created using a genetic algorithm error minimization technique. The performance of the system is then evaluated for known substorm databases.

S1-14

REAL-TIME PREDICTION OF LARGE GEOMAGNETIC STORMS

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Large geomagnetic storms can be particularly damaging to electric power grids, space- and ground-based communications networks, and navigation systems. Large storms can also cause the atmosphere to expand and adversely affect satellite orbits. Like predicting hurricanes, the adverse consequences of incorrect predictions of large geomagnetic storms can be costly. Thus, developing accurate prediction methods is a high-impact and high-visibility objective of Space Weather research. We discuss a method of predicting the occurrence, duration, and strength of large geomagnetic storms using real-time solar wind (SW) data. The method uses Bayesian classification and is based on well-known physical features of geoeffective (storm-causing) SW structures, *i.e.*, long durations of strong southward IMF impinging on the magnetosphere. Using real-time L1 data, the method estimates the geoeffectiveness of the SW upstream of the L1 monitor based on the data that have been measured and calculates the probablility that a storm exceeding a specified threshold in Dst will occur. The results of the tests using historical data, including WIND and ACE data, indicate that accuracy of $70-80$ % is achievable, with warning time of a few hours to more than ten hours, depending on the solar cycle. This is considerably longer than the 1/2-hour geoeffective SW transit time from L1 to the magnetosphere. The method is now being tested at the SEC/NOAA. The formulation of the method and the performance characteristics compiled to date will be shown, and some known failure modes and possible remedies will be discussed. The test results are archived and can be found at http://wwwppd.nrl.navy.mil/whatsnew/prediction/.
Research supported by ONR

S1-15

THE SAPPORO 2000 OLYMPIC SPACE WEATHER PREDICTION CHALLENGE

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The Organizers of Symposium S1, Space Weather: Prediction Techniques, are organizing as a part of that symposium, a Prediction Challenge. Since Sapporo is a site of former Olympic Games, we call it the Sapporo 2000 Olympic Space Weather Prediction Challenge.

The hope is to brightly display the "State of the Art" in Space Weather Prediction Techniques. Details of this event are still in planning and the organizers, welcome comments and suggestions.

The challenge is open of forecasts regarding all aspects of space weather, however we wish to emphasize techniques that can be run in near real-time using available data, and that produce verifiable forecasts. (Verification need not be in near real-time.)

Details and deadlines for entry will be posted at a later date, after they are decided.

Outstanding entries will be summarized by the Symposium and Prediction Challenge organizers in this talk.

Send suggestions, comments, and questions to: Thomas Detman <tdetman@sec.noaa.gov> and Henrik Lundstedt <henrik@irfl.lu.se>

S1-P01

OPERATIONAL MODELS USING A NEURAL NETWORK FOR PREDICTING *Dst* INDEX

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We have constructed the operational models for forecasting the geomagnetic storm index (Dst) two hours ahead on the basis of six parameters of the solar wind: solar-wind velocity V, density N, and X, Y, Z, and the total component of interplanetary magnetic field (IMF) in solar magnetospheric coordinates. It uses an Elman-type neural network. We receive telemetry signals from the ACE spacecraft and send the data to the NOAA to obtain continuous real-time solar wind data for use in forecasting space weather. The time-series data used for training was constructed from data collected for more than 60 strong storms and quiet periods over 9058 hours during the phase of maximum solar activity from 1978 to 1982. Dst forecast used two models have been open to the public since May and December 1998, respectively, and work well using raw-real time solar wind data from ACE. (http://www.crl.go.jp/uk/uk223/service/nnw/index.html). From February to October 1998, there were 11 storms with minimum Dst values below -80 nT. The differences between the minimum Dst as forecast using final processed data from ACE and the final Dst as measured by ground stations was less than almost 20 % for 10 of the 11 storms. The models may be useful as simple simulators to examine the effect of minor effects from B_x and B_y if treated carefully. The dependence of Dst on the IMF angle in the $X - Y$ (GSM) plane seems to give a relatively large Dst for positive B_y. The models are strongly time dependent, so the calculation of a prediction has to start from a quiet period before a storm. Much input contributes to a Dst forecast with the same polarity via every hidden unit in the Elman-type neural network.

S1-P02

SIMULTANEOUS ANALYSIS OF SOLAR TERRESTRIAL MEASUREMENTS

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Simultaneous study of solar terrestrial measurements is very important in the space weather forecast. With this in mind we selected a set of simultaneous solar terrestrial measured parameters (sunspot numbers, solar fluxes at eleven frequencies (namely, 2.8 GHz and ten closely spaced frequencies between 275 - 1755 MHz), Solar wind (IMP-8) and the planetary Ap and Kp indices). We made various statistical analysis of this data set. One of the question that we have tried to address was the effect of solar rotation on these time series ranging from solar photosphere through corona and interplanetary medium to terrestrial environment. The study indicate that corona rotates faster then photosphere and within the corona there appears to be differential rotation in the solar corona as a function of height, in that, the outer corona appears to rotate faster then lower one. It is worthwhile to state that the coronal rotation is derived from the solar radio flux which has $0.79 - 0.91$ correlation (at zero lag) with sunspot numbers The solar wind velocity (IMP-8) and the planetary indices Kp and Ap are found to have solar rotational effect slower then that in corona. The planetary indices also display several other quasi periodic variation which may not be of direct solar origin, but could be due to the complex interaction of solar wind and geomagnetic field. In this paper we will present these results and indicate possible reasons for these temporal behaviours. An attempt will also made on the possibility of using these investigations for the prediction of geomagnetic activity.

S1-P03

MULTI-FACTOR ANALYSIS OF RELATION OF GEOMAGNETIC ACTIVITY TO SOLAR WIND PARAMETERS

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Processing of the 28 year hourly-averaged database reveals numerous statistical relations in behavior of geomagnetic indices and solar wind parameters. Statistical relations between various indices and wind parameters have been obtained. *AE* index appeared to be related to the solar wind velocity for the current hour and with the IMF southward component for the previous hour. The growth rate of *Dst* index is proportional to the dawn-to-dusk IEF under small and moderate solar wind velocities and to the southward IMF under high velocities.

S1-P04

STUDY OF SOLAR WIND-MAGNETOSPHERE COUPLING USING THE FILTERING TECHNIQUE

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Given are the results of application of the prediction filtering technique to the problem of solar wind - magnetosphere coupling. Dependence of the filters' forms on different external and internal conditions (prolonged northward and southward IMF, intermittent IMF, single isolated substorms and substorm sequences) is analysed. The results support a supposition about a non-linearity of the magnetospheric response to changes of the external conditions and testify about an importance of the inner state of the magnetosphere for development and energetics of a single disturbance. Fast and delayed responses of the magnetosphere to variations of the IMF and solar wind plasma have been picked out to distinguish the effects of the near and the far prehistories of the external conditions. It is shown that both effects are important for the disturbance development but differ greatly in their manifestations in the concrete magnetospheric parameter. Besides, a ratio of their contributions depend on external and internal conditions. Applications for the Space Weather needs are discussed. This study is supported by the Russian Foundation for Basic Research (grant 98-05-65120).

S1-P05

PRINCIPLES AND TECHNIQUES FOR SHORT-TERM PREDICTING VARIATIONS IN THE CRITICAL FREQUENCIES OF THE IONOSPHERIC F2 REGION IN MIDDLE LATITUDES EMPLOYING THE SOLAR AND GEOMAGNETIC INDICES

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Short-term variations $dfoF_2$ in the values of the critical frequency of the ionospheric F2 region in middle latitudes due to solar and geomagnetic activities have been investigated. Diurnal and seasonal features of the energy transfer from the auroral into midlatitude ionosphere are revealed. It is shown that they could be taken into account if instead of the 3-hour geomagnetic indices or the ir daily averages a new index, $a*$, is employed which characterizes the average level of geomagnetic activity over intervals of time no less than nine hours usually during the evening and night hours.The proposed indices to a high degree take into account the characteristic features of magnetosphere-ionosphere coupling. As a rule, values of the correlation coefficients, r, between $a*$ and $dfoF_2$ amount to $\sim$0.80 at night and $\sim$0.65 during the day which is significant ly greater than the values being obtained with the use of the standard indices under similar conditions (no more than 0.60 at night and 0.50 during the day, respectively). Also, the 27-day variations in $dfoF_2$ are studied and explained wherefore the 27-day variations in UV radiation are not always in $dfoF_2$ obvious. The investigations performed were used to develop a technique for short-term predictions of variations in values of the $dfoF_2$ in middle latitudes. Errors in the semi-diurnal predictions made with the developed technique under different solar and geophysical conditions are $\sim$1.4 times lower than that with the other techniques employing the solar and geomagnetic indices. The comparison with the technique for predictions [1] using current ionospheric measurements shows that the predictions for more than four hours with the proposed technique are higher accuracy and preferable because there is no need in ionospheric measurements in the given region.

1. *Mikhajlov, A. V., Geomagnetism and Aeronomy*, **30**, 954–957, 1990.

S1-P06

REAL-TIME PREDICTION OF IONOSPHERIC DISTURBANCES CAUSED BY STORMS AND SUBSTORMS

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There are many solar phenomena that eventually cause ionospheric disturbances, most of which are initiated at high latitudes. These changes lead to anomalous of radio wave propagation conditions, which are notoriously difficult to predict reliably. A sophisticated forecasting method has been developed by using real time observations of several HF radio paths (up to 3000 km) with common receiving centre located at the geomagnetic latitude $L \sim 65°$. The technique has the great advantages of simplicity, accessibility and low cost. Various features of the radio signals, *e.g.*, signal amplitude and fading characteristics, are used in real time in conjunction with a channel model. Both short and long-term predictions are possible but the former are better than the latter owing to the lack of long term data series from either polar region, and the impracticality of solving the problems theoretically. The paper will describe in detail the approach used and give some illustrative examples.

S1-P07

NONLINEAR PREDICTION OF SPACE WEATHER USING RADIAL BASIS FUNCTIONS

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A self-adaptive, time-series prediction method using radial basis functions has been developed at DERA and forms the basis of a space weather forecasting demonstrator. This method has several advantages compared with other neural network techniques, such as Multi-Layer Perceptrons, in that the learning process is non-iterative and assured of a global optimum. In addition, methods have been developed to deal with the problems of noise and data drop-outs typical of solar-geophysical data sets. These techniques have been applied to a number of important space weather problems, including prediction of f0F2 and Total Electron Content(TEC) for ionospheric communications, outer-belt electron enhancements of significance for spacecraft internal charging and cosmic-ray fluxes of concern for crew dose and single event effects in spacecraft and aircraft. The accuracy of the models is assessed by using the normalised root mean square error (NRMSE), which enables objective comparisons to be made with other techniques including simple persistence and recurrence models. Particular success has been achieved for self-prediction of hourly-averaged ionospheric f0F2 one hour ahead, with NRMSE as low as 0.2, and for TEC with NRMSE as low as 0.05. For energetic electrons promising results are being obtained using geomagnetic indices and solar wind data. The best results to date utilise *Dst*, *Cp*, sunspot number and the logarithm of > 2 MeV electron flux and achieve a NRMSE of 0.43 when predicting daily-averaged > 2 MeV flux one day ahead. Use of solar wind speed achieves a NRMSE of 0.5 but is currently limited by lack of data. For cosmic rays prediction of monthly values using sunspot numbers and cosmic-ray flux yields significant improvements over persistence and recurrence for predictions between 2 and 12 months ahead.

S1-P08

AN IMPROVEMENT IN STORM FIELD PREDICTION

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Geomagnetic storm field *Dst* has been predicted by various methods including recent new technique such as computer simulation of ring current particles or artificial neural network. From a simple input-output consideration, *Kamide and Fukushima* (1971) tried to predict the *Dst* (DR) field from the *AE* index implicitly assuming that the substorms cause the storm time ring current. On the other hand, *Burton et al.* (1975) predicted the *Dst* field from dawn-to-dusk solar wind electric field in magnetospheric frame, *i.e.*, $-V_x B_s$, where V is the solar wind bulk velocity and B_s denote the southward component of the interplanetary magnetic field (IMF). Both methods were rather successful, and hence, it was difficult to judge which idea is the case. On the other hand, *Iyemori and Rao* (1996) showed a decay of the *Dst* field after the onset of substorms rather than the expected development, and the result was explained as the effect of energy dissipation in the magnetosphere through the substorm process. In this paper, the substorm activity is took into account as an energy loss term instead of the input term for the storm field in a prediction method. The results shows an improvement in prediction efficiency.

S1-P09

THE GEOSPACE ENVIRONMENT DATA ANALYSIS SYSTEM (GEDAS)

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This paper presents our recent efforts of installing a computer system, called GEDAS, at the Solar-Terrestrial Environment Laboratory. This system is intended to conduct "integrated" studies worldwide combining ground-based and satellite-based observations and simulation research. GEDAS is not only a data exchange or data display system, but an efficient research tool. It will also be actively involved in predicting space weather. In this presentation, we show several examples of research projects in which observations are used as the boundary/initial conditions to run simulations on a real-time basis, testing the validity of the assumptions that are employed in the simulations.

S1-P10

SHORT-TIME NEURAL NETWORK PREDICTIONS OF COSMIC RAY NEUTRON MONITOR RESPONSES TO SOLAR ACTIVITY MODULATION FROM SOLAR WIND DATA

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The responses of ground based cosmic ray neutron monitors to solar activity modulation are modelled and predicted with artificial neural networks. The prediction time-scales ranges from zero (nowcasting), to hours (hourly averages), and to $1-3$ (a few) days (daily averages). Several neutron monitors with different cut-off rigidities and geographic locations are treated.

Time series of solar wind measurements, obtained from the OMNIweb database, are used as inputs to the neural networks, which in turn gives modelled or predicted neutron monitor response as outputs. Three different kinds of neural networks are evaluated with regard to overall (statistical) performance, performance on specific cases, computational complexity, and the amount of input data required. The purpose is to find networks that performs well but requires both a minimum amount of complexity and input data. Included networks are: Multi-layer perceptron with time-delay, Finite Impulse Response network, and ELMAN recurrent network.

Solar activity phenomena (CMEs, magnetic clouds, shocks, ejecta), with different levels of geo-effectiveness, transmitted by the solar wind give rise to distinct signatures in the input time series. In order to identify corresponding neutron monitor response, both correlative studies and superposed epoch analysis are employed. Specific event selection for testing purposes are done separately from neutron monitor data and from geomagnetic data.

S1-P11

NEURAL NETWORK PREDICTION OF GEOSYNCHRONOUS RELATIVISTIC ELECTRON FLUX FROM SOLAR WIND DATA

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Electrons with MeV energies are believed to cause deep dielectric charging of spacecraft at geosynchronous orbit. The charge build-up and the subsequent discharge may cause damage to the spacecraft. In this work we show how hourly averages of the > 0.6 MeV and > 2 MeV electron flux can be predicted from solar wind data several hours in advance. Specifically we use the OMNI and ACE solar wind data sets, and the GOES-08 and -10 electron data. As the variance of the electron flux is very different for different local time sectors the model must take this into account. Thus, the model consists of expert neural networks each predicting the electron flux for a certain local time. Even though the GOES satellite only samples the electron flux at one specific local time sector at any given time, the model can generalize so that predictions can be made for any local time sector. The predictions are compared with measured data for a few test periods.

S1-P12

ARTIFICIAL NEURAL NETWORK APPLICATIONS FOR NOWCASTING AND FORECASTING OF THE SPACE WEATHER

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Artificial neural networks (ANN) are applied for modelling different aspects in the solar-terrestrial linking and are used for space weather diagnostics and prediction. Recurrent Ehlman neural networks are successfully used to predict the long time dynamics of the current XXIII solar cycle and average dynamics of the solar wind plasma and interplanetary magnetic field. Modelling of the solar wind magnetosphere interaction by means of general regression neural network permits to represent dynamics of the Earth's magnetopause and inner magnetospheric radiation. ANN models and comparison of their applications with experimental data are presented.

S1-P13

IMPROVED *Kp* AND *Dst* FORECAST USING ANFIS TECHNIQUES

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This presentation will present results of Adaptive Neuro Fuzzy Inference Systems (ANFIS) techniques applied to the short term (< 24 hr) prediction of the *Kp* and *Dst* indices. The techniques developed make use of the long term archives of magnetics, indices, and satellite data available through NGDC. The techniques achieve maximum effectiveness by combining a fuzzy logic based "expert system" with the automated neural network to produce the final prediction. The results achieved using the models are presented and contrasted with other current *Kp* and *Dst* prediction methods such as US Airforce models. Additionally "mutual information" data is presented outlining the percieved importance of the observation variables in the final predictive capabilities.

S1-P14

THE USE OF ONE-MINUTE DATA OF EMILIO SEGRE OBSERVATORY (ISRAEL) OF TOTAL AND DIFFERENT NEUTRON MULTIPLICITIES COUNTING RATES FOR AUTOMATICALLY SEARCHING THE START OF DANGEROUS FLARE ENERGETIC PARTICLE EVENTS

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We describe the method continuously used in Emilio Segre' Observatory in Israel for searching the start of great Flare Energetic Particle (FEP) events which could be dangerous for electronics on spacecrafts. It is shown that the probability to obtain wrong Alert is very small, and that, for totally excluding this possibility, we check the predicted start of FEP event by using a few one-minute data. We use data separately of two neutron monitor sections, as well as data from both sections of different multiplicities from 1 to 8. We applied the developed method to some great historical FEP events. We show, on the basis of data obtained by neutron supermonitors on Mt. Gran-Sasso (Italy) in the period of great historical Flare Energetic Particle (FEP) event September 29, 1989, that the start and some rough characteristics of this event can be determined by using one-minute data of total intensity and data of different multiplicities. It is shown that, by a few minutes of data, more exact information and better forecast of developing of FEP event can be obtained for much bigger FEP events similar to the greatest event (February 23, 1956) observed

in the last 60 years. On the basis of the obtained information in the first few minutes on the great FEP event, it will be possible, by the well known method of coupling or response functions, to recalculate the ground-based data to the expected flux out of the atmosphere, and out of the Earth's magnetosphere, and to determine the flux at the source and propagation parameters, and then to predict dangerous situation as a function of time and type of spacecrafts.

S1-P15

PREDICTING HIGH-LATITUDE GEOMAGNETIC DISTURBANCE PATTERNS USING NEURAL NETWORKS

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The peak geomagnetic activity occurring in the northern auroral zone can be related to prior solar-wind conditions, as demonstrated by the success of nonlinear models for prediction of the AE, AU, or AL indices. The geomagnetic AE indices are, however, limited to the time domain. They do not give any information about the location of the peak activity, or about the simultaneous activity at other locations. For some purposes, this neglect of the spatial domain may limit the usefulness of the prediction models.

We are currently studying the use of ANN techniques for prediction of the geomagnetic disturbances that are observed at particular locations or at a latitudinal chain of magnetometer stations. The methods employed are generalizations of those used previously by *Gleisner and Lundstedt* [1997] for prediction of the AE index. After subtraction of secular trends, the quiet-time daily variations are removed from the observed geomagnetic records using radial-basis function networks. The horizontal disturbance components are then modelled with gated time-delay networks taking local time and solar-wind data as primary input. Specialized networks are used to make predictions that are valid for different domains of the output space. Gating networks then synthesize the specialized predictions into a single predicted value. The observed geomagnetic field is not used as input to the networks, which thus constitute explicit nonlinear mappings from the solar wind to the geomagnetic disturbance field.

S1-P16

FORECASTING GEOMAGNETIC STORMS USING ENERGETIC ION ENHANCEMENTS: CONTINUED

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Energetic ion enhancements observed by interplanetary satellites in the $\sim$ 50 keV energy range are known to be due, in part, to ion acceleration in interplanetary shocks as the shocks propagate towards 1 AU. Thus the observation of these enhancements at satellites located at L1 can be considered as a tool for forecasting the arrival of interplanetary shocks at Earth and the start and intensity of geomagnetic storms in the Earth's magnetosphere. In previous work, the signatures of energetic particle enhancements were studied together with the accompanying interplanetary shocks and geomagnetic storms. Forecasting guidelines were formulated on the basis of WIND data during the time-period 1995 – 1998 and ACE data from launch through 2/2000. We extend this work by including recent ACE events, investigating the nature of the interplanetary drivers and the behaviour of B_z. We also investigate the accuracy in timing; demonstrating the ability of this technique to predict geomagnetic storms. These enhancements in ion intensity may be seen, starting at lower flux intensities, up to several days in advance of the arrival of the shock. Establishing a threshold value for the flux to reach greatly reduces the monitoring-time, while still providing warning time of hours or even days in advance of a geomagnetic storms.

S1-P17

REAL-TIME UPDATING OF THE MID-LATITUDE IONOSPHERIC TROUGH MODEL

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The mid-latitude ionospheric trough phenomenon affects ionospheric and trans-ionospheric telecommunication. The particular importance of its simplified model in foF_2 instantaneous maps for HF radio-communication application had been shown and recommended for the use. Further developments of the current updating of the position and the proportions of the trough is shown by use of the PLES modeland ground based ionosonde measurements.

S1-P18

RESULTS FROM GLOBAL MHD SIMULATIONS FOR SPACE WEATHER MONTH

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Global magnetohydrodynamic simulations have been used to study the coupled solar wind - magnetosphere - ionosphere system for well over a decade and are now making accurate qualitative and quantitative predictions of the state of the magnetosphere - ionosphere system under a variety of solar wind conditions. The month of September 1999 was highlighted for study as Space Weather Month. Using a real-time version of the Lyon-Fedder-Mobbary (LFM) global MHD code we have simulated the interval from September 11th to September 24th. This peroid is particularly interesting because it contained a major magnetic storm, significant density pulses, interplanetary shocks, and a CME. In our collaboration with the Space Enviroment Center we have identified the strength and location of the ionospheric electrojets and the location of the dayside magnetopause as potential data products from the simulation that could be used in space weather forecast centers. This talk will concentrate on validation of these products through a direct comparison with observations. In the ionosphere the results are compared with ground based magnetometer measurements and convection observations from SuperDARN. In the magnetosphere we will compare magnetopause crossings observed by LANL and ISTP spacecraft with the predictions made by the LFM. Where possible the long duration run will be used to compute metrics as quantitative measurements of the simulations success during this interval. These results will have a significant impact on the utilization of the LFM as a space weather prediction tool.

S1-P19

FORECASTING EVOLUTION OF *Dst* INDEX FROM SOLAR WIND MEASUREMENT USING SUPPORT VECTOR METHODS

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Empirical nonlinear models are used for forecasting the evolution of Dst index using parameters of the solar wind, VB_z and p, as the model inputs. The advantages of including recent measured values of Dst as initial conditions for short term forecasts are also illustrated. The model that is free of initial condition requirements is based on high-order Volterra models while the model requiring initial conditions is based on the nonlinear autoregressive with exogenous inputs (NARX) structure. Recently introduced kernel (support vector) methods are used to optimise these possibly high dimensional model structures. The methods allow some straightforward analysis of the underlying physics in the form of generalised frequency responses. Other advantages features over previously tried methods are convexity in optimisation, built in resilience to overfitting, and confidence bounds for predictions.

S1-P20

FORECASTING EVOLUTION OF *Dst* INDEX FROM SOLAR WIND MEASUREMENT USING NONLINEAR ADAPTIVE FILTERS

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A novel nonlinear adaptive filtering technique provides prediction of future values of Dst index from recent measurements of the solar wind parameter, VB_s, and Dst. Short to medium term forecasts are produced using nonlinear models that are adapted to the most recently available measured data. This adaptive filter approach has particular application in the field of magnetic storm prediction as a result of its ability to become locally 'tuned' to current dynamic behaviour. The model optimisation is simple and convex and provides accurate prediction many hours ahead of measured data. The adaptive filter method is also applied to the prediction of future values of VB_s and the concatenation of the two filters to predict Dst is implemented. It is further shown to be able to provide a globally useful, static model similar to those obtained by other nonlinear modelling techniques.

S1-P21

FINAL VALIDATION RESULTS AND DATABASES FOR TWO SOLAR EVENT-INITIATED INTERPLANETARY SHOCK PROPAGATION MODELS

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Three databases have been compiled for interplanetary shock propagation studies. The first (inputs) is comprised of all type II radio sweep events and associated solar activity from Nov 1984 through the end of 1998. The second database (outputs) contains predicted arrival times and amplitudes of shocks at 1 AU for the Interplanetary Shock Propagation Model (ISPM) and Shock Time Of Arrival (STOA) model. The third database (observations) is a compilation of IMP 8 and WIND satellite-observed shocks and ground-based magnetometer-derived sudden storm commencements (SSCs) from 1988 through 1998. These databases are used to validate the shock propagation models, to estimate the average sun-to-earth shock transit time, and to correlate 1 AU shocks with observed SSCs.

The input database contains all reported Type II Sweep radio bursts corresponding to 912 distinct solar events, along with event-correlated conventional and non-conventional Hα, Goes X-ray, and applicable Solar Maximum Mission (SMM) coronagraph data. Criteria used in associating the solar observations are presented. The models were run for all allowable input data configurations of event start time, drift speed, location, and shock driver duration - nearly 5000 runs per model. The satellite observations database contains shock information derived from changes in density, velocity, temperature, and magnetic field. Over 500 shocks and additional SSCs are listed, with qualities ranging from excellent to very poor.

Database statistics are gathered, and comparisons made between the model predictions and observations. Our subset of most time-separablecases are unambiguous, with a 4 to 6 day window of isolation for initiating solar type II sweep events. A special set of cases (with very similar inputs, yet very different transit times to 1 AU) indicates that spacial and/or temporal variations in the solar wind velocity or magnetic field may affect the applicability or accuracy of the models.

S1-P22

SOLAR PROTON FLUX FORECAST

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A review of some space weather contributions about solar proton flux forecast are presented. These contributions are:

1. Forecasting and software general conception: Like independent variables the radioemission in centimetric and metric band and the flare heliolongitude are used; the radioemission as an indicator of acceleration degree of charged particles, and the heliolongitude as an indicator of the emission region location. Their values are used like software input data. The operative time needed to obtain the proton flux forecast of one solar burst are less than 15 minutes after the microwave radioemission maximum is recorded. The forecast present preliminary qualitative prediction – proton or not proton event –. For proton events predict the maximum intensity, the energetic spectral index and, the times of arrive at Earth of: the start, maximum and 37 percent of maximum of intensity levels.

2. Software application to retrospective analysis with independent data to 18 solar events of the period 1988 – 1990, showing good agreement between observed and calculated values, also in the cases of complex activities of March and October of 1989.

3. Software operative time application to 12 solar events recorded at the Havana Radioastronomical Station (ERH) during the period 1991 – 1993 with good agreement between predicted and later observed values. Considerations about new proton flux parameters algorithms and software are also included.

S1-P23

A "3-B" METHOD OF GEOMAGNETIC DISTURBANCE PREDICTION

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A "3-B" method of the geomagnetic disturbance prediction is suggested in this paper. It is a combined approach from the observational bass-Solar activity/interplanetary scintillation (IPS) observations, physical base – 3-dimension characteristics of the propagation of the interplanetary disturbances and mathematical base – membership function sets established according to the observational data in 1966 – 1982. Main results of the prediction test are that (1) for 37 events during the solar activity descending phase 1984 – 1985, onset time – for 50 % of all events, relative error, $?T/T?10$ and for 70, $?T/T?20$; disturbance magnitude – for 80 % of all events, $??kP/?kP?30$, and only for 15, $??kP/?kP?60$; (2) for 24 events that have caused the important space adverse during the period of 1980 – 1989, onset time – 11 events for $?T/T?10$, 8 events for $10??T/T?30$; disturbance magnitude – 10 event for $??kP/?kP?60$, 8 events for $10???kP/?kP?50$ This shows that the "3-B" method suggested has encouraging application prospect.

S1-P24

PREDICTION OF THE SUNSPOT MAXIMUM FOR SOLAR CYCLE 23

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Among the various methods of predicting the magnitude of sunspot maximum, Ohl's precursor method, where the precursor is the geomagnetic activity in the declining phase of the previous cycle, seems to give the most accurate predictions. For the present solar cycle 23, Kane estimated the maximum smoothed sunspot number as $\sim$ 152. However, another method, based upon extrapolation of selected periodicities obtained from spectral analysis of earlier data, also gives similar results. Kane used Maximum Entropy Spectral Analysis combined with Multiple Rregression Analysis and gave an estimate of $\sim$ 140, to occur in the middle of year 2000. Rangarajan used the sophisticated method of Singular Spectrum Analysis and gave an estimate of $\sim$ 130. Thus, a value in the range $130 - 155$ is expected. At the time of the writting of this abstract, the smoothed sunspot value seems to be around 100. It remains to be seen whether it will increase to $\sim$ 140 in the next few months. By the time of the conference (October 2000), a better picture should emerge.

S1-P25

PERIODICITIES IN THE TIME SERIES OF SOLAR EMISSIONS AT DIFFERENT SOLAR ALTITUDES

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A spectral analysis was done of the time-series of daily values of ten solar coronal radio emissions in the range $275 - 1755$ MHz, several UV emission lines in the chromosphere, the 2800 MHz radio flux, and sunspot number, for six successive intervals of 132 days each, during June 1997 - July 1999 (26 months). The spectral characteristics were not the same for all intervals. In particular, the 27-day solar rotation signal was missing in some intervals, indicating that the solar events were sometimes short-lived. Other periodicities observed were in the range $11 - 16$ days, 35, 40, $50 - 70$ days. Periodicities were remarkably similar in many of these indices, indicating that the solar atmosphere rotated as one block, upto a height of $\sim$150,000 km. Above this height, the periodicities became obscure. Near the solar surface, sunspots showed extra periodicities, which fizzled out at low altitudes.

S1-P26

DATA ASSIMILATION TECHNIQUES IN THE LOW LATITUDE IONOSPHERE: ESTIMATION OF VERTICAL $E \times B$ DRIFTS FROM OBSERVED IONOSPHERIC PARAMETERS

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The DoD has recently funded a five year, Multi-disciplinary University Research Initiative (MURI) to develop a global ionospheric data assimilation model. Under the auspices of this program, a consortia of universities headed by Utah State University (USU) is developing a Global Assimilation of Ionospheric Measurements (GAIM) model. Working on this GAIM effort, we are evaluating several potential techniques to deduce low-latitude vertical $\boldsymbol{E} \times \boldsymbol{B}$ drifts over the 24 hour day from measured ionospheric parameters (foF_2, H_{max}, etc.). One approach is to observe the time-dependent behavior of the bottomside electron density profiles measured by a digital sounder at the magnetic equator. Another is to use neural networks trained on model data to estimate the vertical $\boldsymbol{E} \times \boldsymbol{B}$ drift curves. A third is to train an "adaptive filter" algorithm on model data to estimate vertical $\boldsymbol{E} \times \boldsymbol{B}$ drift curves. All three of these methods show promise in future forecasting applications, and are presented here.

S1-P27

RADIOHELIOGRAPHIC DIAGNOSTICS OF SOLAR FACTORS THAT DETERMINE AND DISTURB THE SPACE WEATHER

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The character and degree of geoeffectiveness of the various manifestations of solar activity, which determine and control the state and variability of the space weather, depend on many conditions on the way from the solar atmosphere to the Earth. These conditions, when realized, are responsible for the individual characteristics of events in solar-terrestrial relationships. It has been unfeasible to predict them unambiguously to date. Therefore it is necessary to have a continuous monitoring of solar activity and its consequences. All-weather monitoring of solar activity is most practicable (as regards costs) and efficient, based on using radioheliographs providing simultaneous recordings of phenomena and processes in the solar atmosphere at all its levels (specifically, in the corona against the solar disk), at all spatial, temporal and energy scales. Daily observations of this kind, which were carried out from morning to evening, were instrumental in gaining further insights into the character of the initiation of active regions, identifying flare buildup indicators, developing a technique for predicting powerful flares, studying the character of the manifestation of coronal holes at different levels in the solar atmosphere, recording coronal mass ejections against the background of the solar disk, etc. These developments are exemplified by original data obtained at the Siberian Solar Radio Telescope (SSRT) in conjunction with the data from Nobeyama Radioheliograph. Unfortunately, the utilization of such data, and the issueing of alerts and forecasts of flare buildups, the appearance (disappearance) of active regions at solar limbs several days in advance, the solar disk passage of coronal holes, filament activation, and CMEs in real time is made difficult mainly by the inadequate communications means available to the ISTP Radioastrophysical Observatory. A substantial improvement to the efficiency and information content of the solar activity monitoring at the SSRT is possible upon completion of the modernization currently underway, with its subsequent conversion to a multiwave radioheliograph, a new-generation instrument.

S1-P28

POSSIBLE TRIGGER OF SOLAR FLARES

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Coronagraphic observations by SOLWIND, SMM and SOHO indicate the presence of a continuous stream of comets either passing near the solar surface or colliding with the Sun. We investigate analytically the possibility of triggering of solar flares in the region of sunspots by sungrazing comets. Calculations show that within the solar chromosphere and photosphere fully fragmentation of a cometary nucleus and its transversal expansion occur due to action of aerodynamic pressure. This process is completed by intense aerodynamic deceleration and explosion of the essentially flattened nucleus in the relatively very thin subphotosphere layer with generation of a strong shock wave. The energetics of the process corresponds to energetics of solar flares. We conclude that some solar flares in sunspots may be triggered by shock waves from explosions of cometary nuclei. Coordinated observations of sungrazing comets and the Sun with high spatio-temporal resolution seem important for the problem of prognosis of solar flares.

S1-P29

A STATISTICAL MODEL OF THE ANNUAL MAGNETIC STORM OCCURRENCE

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We identify the statistical model for magnetic storm occurrence. Magnetic storms were identified using the *Dst* index. The occurrence of moderate to severe magnetic storms with peak values less than -65 nT was found to be a random stationary (Poisson) process for $2-3$ year samples, but the corresponding Poisson statistic was found to slowly vary on solar cycle time scales. The model can be used to successfully predict the annual occurrence rate of magnetic storms up to 3 years ahead.

S1-P30

TREND, NON-STATIONARY CYCLES DERIVED IN SELF-CONSISTENT STUDY OF SUNSPOT NUMBERS AND PROBLEMS OF FORECASTING

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MGM method of non-linear spectral analysis, was used to calculate a spectrum in the annual Wolf sunspot numbers W for the time from 1700 to 1999 yr. MGM is capable of making a self-consistent selection of trends from a data set and singling out harmonics with varying phase and amplitude. It is very important – a correct extraction of a power trend determines the results of the model prediction on the whole. It is shown that the most of the non-stationary sinusoids in spectra have statistical significance (confidence level > 98). The time intervals in behaviour of non-stationary harmonics, on which it is seen the time boundaries of the wave trains of these harmonics and phase catastrophes are indicated. The non-linearity of generation of these harmonics is shown. The trend is the powerest and described by a cubic parabola. The non-stationary harmonics at periods 12.6, 8.6, 6.6, 5.3, 4.6 (in years) are in the spectrum. The MGM allows the determination not only such well-known periodicities in the spectrum as the solar 10.97-yr., the 10.74-yr. and 11.89-yr. cycles, but also for the first time the secular 95-yr. and 61-yr. cycles. The forecasting the 23rd solar cycle is given and discussed. It is shown that the errors in determination of the trend parameters play the key role in errors of the prediction technique. These errors can change the predicted behaviour of the 23rd cycle. However, the length of W is not enough for correct description of the trend. It is shown that comparative analysis of the long data sets (C^{14}, global temperature, geomagnetic field) allows to improve prediction technique, because of the powerest long-periodic changes are reflected in all spectra and have a resonance nature.

S1-P31

COMPARISON OF METHODS FOR SOLAR CYCLE PREDICTION

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Despite a large number of methods available, predicting solar cycles months or years in advances remains one of the challenges of the prediction. Methods using geomagnetic activity as a precursor of solar cycle maximum amplitude seem to give disappointing results for the present time, compared with previous cycles. The temporal evolution of the predictions for cycle 23 is compared to the state of the cycle at the time of the workshop, showing the interest to multiply independent approaches, rather than to select a specific method.

S1-P32

ARTIFICIAL NEURAL NETWORK TECHNIQUE FOR PREDICTION OF SOLAR ACTIVITY INDEXES FOR DIFFERENT TERMS

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In the given work, we analyze the application of Elman artificial neural networks (ANN) for prediction of temporary series of monthly number of sunspots for different terms. Taking into account physical dependence of various types of solar activity from sunspot number, the data on other indexes of solar activity: the Zurich classes, classes of penumbraes, classes of configurations, 2800 MHz Solar Flux, Hα Solar Flares and others were included in a sequence of input units of ANN. The applicattion of these data for construction of forecasts of temporary series of sunspots for different terms was limited by accessible to us and reliable from modern positions intervals of definition of these indexes: from 50 till 100 years. This feature was considered at realization of ANN training process. The variation of hidden units in quantity, feedback switching-on and off, modeling of influence of prehistory of investigated process by the method when indexes obtained for the previous time intervals are given on the series input neurons, was carried out. As a result of application of chosen ANN, it was possible to execute satisfactory training and forecasting of relative number of solar sunspots for the intervals of six months, six years and the whole 24 cycle. In the first case for obtaining of the best result, as it seemed to us during test checks, it was required to choose the maximal number of indexes as input units. In the last the training for successful test prediction was conducted mainly on the basis of monthly relative sunspots' number obtained for last four cycles of solar activity.

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S1-P33

FORECASTING DANGEROUS SITUATIONS FOR SPACECRAFTS AND AIRCRAFTS CAUSED BY LARGE SOLAR ENERGETIC PARTICLE EVENTS

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The issue of reliable forecast of large solar Flare Energetic Particle (FEP) events for the protection of the electronic components in spacecraft and aircraft is considered. During a large FEP event radiation levels in a spacecraft or in a high altitude aircraft can increase to such high levels that electronic components may be damaged. In these periods it may be crucial to switch off the sensitive components for several hours in order to minimize the damage. The problem is how to forecast reliably such an event. We show here that a reliable forecast can be made by using high-energy particles (few GeV/nucleon and higher (whose transport within the interplanetary space is characterized by a much higher diffusion coefficient than particles with smaller energy. Therefore these high-energy particles reach the earth $8-20$ minutes after accelerating in the Sun and escaping into the solar wind, $30-60$ minutes earlier than the smaller energy particles which are especially dangerous for electronics. We describe here the principles and the main features of an automatic FEP-Searchprogram. The exact onset of a large FEP event is determined automatically by simultaneous increase with an amplitude of at least 2.5 St. Dev. in two or three sections of a neutron super-monitor. The FEP-Searchprogram also uses data from the next 2 minutes to ensure that the observed increase indeed indicates the beginning of real large great FEP. If this is confirmed, the FEP-Research, 1st-Alert program in invoked. This program makes an approximate determination of the main parameters of the event, including a very rough forecast of the expected increase in the radiation levels in the nearest hour, based upon the earlier three 1-min data. If the expected level of radiation is dangerous, a 1st-Alert (3 minutes after the beginning of the event) will be signaled. In any case the program FEP-Research-2nd Alert will be activated and it will use data corresponding to the first

5 minutes to give a more precise forecast of the event parameters. Similarly programs FEP-Research-3rd Alert FEP-Research-4th Alert and so on will give increasingly more precise forecasts based on the data from the first 10, 15 or more minutes.

S1-P34

IMPROVING SOLAR PROTON EVENTS STATISTICAL MODELS

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Long term prediction of solar proton events are useful to evaluate accumulated effects of such protons on space systems or to optimize space operations like astronomy observations or manned missions. Several models have been developed the last 25 years among which the most popular one is the so-called JPL-91 model [*JGR*, **98**, 13,281–13,294, 1993] based on IMP and OGO spacecraft measurements between 1963 and 1991. The various statistical models will be briefly reviewed. The current limitations will be discussed and some possibility of improvements based on the use of more data or other approaches will be presented.

S1-P35

PREINCREASE EFFECT BEFORE FORBUSH-DECREASE AS A PHENOMENON IMPORTANT IN SPACE WEATHER FORECASTING

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In the paper the results of investigations in this field up to now are summarized. Moreover the time-dependent transport equation of cosmic rays in the heliosphere is numerically solved in order to determine the influence of enhanced magnetic field strenth and solar wind speed for the increase of galactic cosmic ray density before Forbush effect. Several cases of preincreases observed during the interval last solar cycle are analysed by means of global survey method and the amount of changes of intensity and anisotropy are estimated. The possibility of utilization of the preincreasies in space weather forecasting is discussed. Additionally we emphasise the importance of such a forecasting from point of view human health. We report our result of the 12.2 % increase of the number of the myocardial infarction cases during geomagnetically disturbed days.

S2-01

GEOEFFECTIVENESS OF CMEs

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Among the several hundreds of CMEs observed by the LASCO instruments onboard the SOHO spaceprobe a significant percentage was of the "halo" type, *i.e.*, they were pointed towards or away from the earth. Only additional evidence from further instruments observing the disk appropriately, in particular EIT on SOHO, allows to predict which halo might become geoeffective. We measured the lateral expansion speeds of some tens of halo CMEs in order to infer their otherwise unaccessible radial speeds. We compared these numbers with average propagation speeds derived from the time difference between the CME and the occurrence of their associated shock waves at 1 AU. It turned out that the variance of expansion speeds close to the sun is significantly higher than that of the average propagation speeds. The geoeffectiveness of CMEs driving shocks towards the earth is extremely variable. It all depends crucially on the topology of the magnetic field topology within the shocked plasma and the succeeding driver plasma. The location and orientation of the magnetized source region of a CME might be used for more precise prediction of its probable geoeffectiveness.

S2

S2-02

3D MHD MODELING OF THE SOLAR DRIVERS OF SPACE WEATHER

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Novel upwind residual distribution schemes have been developed for solving the time dependent three-dimensional magnetohydrodynamic (MHD) equations on unstructured grids. These monotone multidimensional schemes are especially developed for space weather applications, in particular for the simulation of the solar wind and the initiation and evolution of coronal mass ejections (CMEs) in the framework of a project investigating the physics of the solar drivers of space weather.

The purpose of this project is to reveal the basic physics behind the recurrent structure, heating and acceleration of the solar wind and the formation and propagation of transients like CMEs and induced shocks from their birth in the solar corona up to their arrival at the Earth's magnetosphere. This should provide a basis for more reliable science-based space weather predictions.

The novel numerical techniques are briefly discussed and their advantages and superiority are demonstrated by means of the first results of the above-mentioned project, viz. the simulation of the solar wind, complex MHD shock interactions associated with fast CMEs, and the solar wind interaction with the Earth's magnetosphere.

S2-03

AN EMPIRICAL MODEL TO PREDICT THE ARRIVAL OF CORONAL MASS EJECTIONS AT 1 AU

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The interaction between coronal mass ejections (CMEs) and the solar wind can be quantified as an effective acceleration acting on the CMEs. Based on this acceleration, we obtain an empirical model to predict the arrival of CMEs at 1 AU. We test this model using past observations from Helios, P78-1, Pioneer Venus Orbiter and Solar Maximum Missions. We also discuss the geoeffectiveness of the CMEs that arrive at 1 AU.

S2-04

PREDICTING BOW SHOCK AND MAGNETOPAUSE LOCATIONS DERIVED FROM EMPIRICAL MODELS AND REAL-TIME SOLAR WIND DATA

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Over the years many empirical models have been developed to describe the average locations and shapes of the Earth's bow shock and magnetopause. Several of these models are parameterized according to the external conditions of the solar wind. Because these models are comparatively simple, they can be calculated quickly and provide reasonable though crude estimates of the shapes of the geophysical boundaries. By describing the solar wind as a sequence of 'fronts', one can estimate several shapes of the geophysical boundaries at a given moment of time. Assuming each boundary shape is most accurate at the location of each 'front', one can piece together boundary shapes, thus providing shapes which coarsely represent the dynamics imposed by the solar wind. Real-time solar wind observations taken far upstream of the Earth are then used to predict boundary locations into the near future. We describe the strengths and weaknesses of using such empirical models in a dynamic manner to forecast the locations of the geophysical boundaries, and how they are being used for the purposes of space weather.

S2-05

ON SPACE WEATHER ENERGY BUDGET

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Determination of the magnetospheric energy budget is a difficult task because the energy input cannot be directly measured. The input-rate is often parameterized in terms of Akasofu's epsilon parameter, which is given as a function of upstream Poynting flux toward the magnetosphere. The scaling of the parameter as the input power was originally estimated by considering power of different energy sinks within the magnetosphere. While more recent studies have refined our knowledge of the sinks, epsilon has maintained its role as an easily determined input estimator. In this study we discuss certain issues about the epsilon parameter, which are not always appreciated when using the parameter. We analyze the Poynting flux in the upstream solar wind and discuss how it becomes incident on the magnetopause, considering the draped magnetic field configuration in the magnetosheath. While we cannot determine the exact amount of flux penetrating through the magnetopause, it is clear that the flux must be collected from a relatively large area if it really is to be considered as the source of magnetospheric energy. Furthermore, in order to be consistent with the interpretation of the epsilon parameter in terms of Poynting flux, it is necessary to exclude the Sun-Earth magnetic field component from the calculation. A further complication is that the effective area through which the Poynting flux can penetrate through the magnetopause cannot follow the changes in the upstream magnetic field direction with a constant time delay due to finite speed of the magnetosheath flow. Thus we argue that it is more physical to use the epsilon parameter as an integral over a given, *e.g.*, storm or substorm time-period (energy) than as a measure of an instantaneous input rate (power).

S2-06

MHD SIMULATIONS OF SUBSTORMS FOR SPACE WEATHER

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A goal of the Space Weather Program effort at Communications Research Laboratory (CRL) is to increase our physical understanding of the solar wind-magnetosphere-ionosphere (S-M-I) coupling system. In recent years, the global magnetohydarodynamic (MHD) simulation has become increasingly successful at reconstructing and predicting behaviors of the S-M-I system. It will implement a useful tool for practical space weather applications. To make these outcomes more fruitful, it is unavoidable to achieve a satisfactory success in reproducing the substorm in the numerical model. Starting from a stationary solution under a northward interplanetary magnetic field (IMF) condition with non-zero IMF B_y, our model reproduces the substorm after the southward turning of the IMF. At first, the plasma sheet thinning is promoted by the drain of closed flux from the plasma sheet under the enhanced convection. The onset occurs as an abrupt change of pressure distribution in the near-earth plasma sheet and an intrusion of convection flow into the inner magnetosphere. It is concluded that the dipolarization is not a mere pile up of the flux ejected from the NENL but the state (phase-space) transition of the convection system from a thinned state to a dipolarized state associated with a self-organizing criticality.

S2-07

CAN WE TRACE THE SPACE-WEATHER CONDITIONS BY THE GROUND-BASED GEOPHYSICAL OBSERVATIONS?

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The reliable and low-cost method of monitoring such important solar wind parameters as the interplanetary magnetic field (IMF) and its dynamic pressure can be ensured by the specially designed ground-based geophysical observations. The PC-index (derived from the ground-based polar cap geomagnetic observations) chracterizing magnetic activity in the polar cap is a dimensionless value parameterizing by the season, UT moment, and hemisphere. It has been calibrated for interplanetary electric field $E = (V[B_z^2 + B_y^2])$ value which merges into the magnetoshere. The PC-index calculated automatically with 1-minute resolution can serve as a proxy for such magnetospheric parameters as the cross-polar cap voltage, ionospheric electric field in the near-pole region and hemispheric Joule heat value. The daytime ionization level of the F2-region of the polar ionosphere is another easily measured parameter, which is proportional (with correlation degree more than 80) to the subsolar distance between the Earth and the magnetopause. There are the strong reasons to believe that this subsolar distance together with magnetopause shape determine amount of the solar wind energy transferred into the "magnetosphere-ionosphere-atmosphere" system. Additionly, the riometer observations of the polar cap absorption events (PCA) are the indicators of the solar cosmic rays energy penetrated into the near-Earth space. Consequently, the regular geomagnetic, ionospheric and riometer observations in the near-pole region can provide an adequate information on the current state of the magnetosphere in the regime of quasi-real time.

S2-08

REALTIME MONITOR FOR AURORAL KILOMETRIC RADIATION: RELATIONSHIP WITH SUBSTORMS, PROPAGATIONS IN THE VICINITY OF THE EARTH, AND REALTIME MONITOR SYSTEM

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Magnetospheric substorms often bring us a variety of troubles and disasters to human activities both on the Earth and in the space. One of the strongest impacts occurred during the last solar cycle in 1989, when the entire Province of Quebec went dark because a geomagnetic storm caused power lines to overload. In space, astronauts often face hazards when venturing outside the safety of the space shuttle and need to be alerted to the dangers of energetic particle emissions from the sun. Herein, we propose a system to monitor Auroral Kilometric Radiation (AKR) by spacecraft in the vicinity of the Earth. The AKR is one of the well-known plasma waves radiated form the Earth, and deeply related with substorm activities. With our system we can detect the onsets of the substorms within few minutes and this information is delivered through the Internet. In our talk, we first introduce event studies and statistic studies to demonstrate how the AKR is related to the substorm phenomena. Then, we show how the AKR looks like on the POLAR satellite orbits; there are regions where the AKR is unreachable in the vicinity of the earth. After comparison with AKR observations via GEOTAIL satellite, we can estimate the area where the AKR is occulted by the plasmapause both in the dayside and nightside. Clear relationships between the "sizeh of the plasmapause and AKR occultation regions are found in both sides. Finally, taking into account the AKR properties, we propose the AKR onset monitor system. We hope this system will contribute to the space weather forecasting and substorm "nowcastingh.

S2-09

SCOSTEP S-RAMP SEPTEMBER 1999 SPACE WEATHER MONTH CAMPAIGN: OVERVIEW OF EVENTS, WORKSHOP INTERFACE, DATA SETS AND STUDIES UNDERWAY

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September 1999 Space Weather Month was created by SCOSTEP/ S-RAMP to identify a one-month period during which international efforts could be focused on coordinated space weather observations and subsequent analysis. There were roughly three periods of shocks, ejecta and southward interplanetary magnetic fields that triggered magnetic storms during the core campaign interval in September 1999. This resulted in 4 moderate and 1 major magnetic storm. A fifth moderate storm period followed at the end of the month. A major magnetic storm in late October 1999 has also been folded into the campaign because of its impact on ground systems and the existence of data sets not available in September 1999. The campaign had a number of special features including: participation by a wide variety of ground-based observing facilities world-wide, optimized satellite coverage from the ISTP project and Ørsted, an embedded 3-day interval of coordinated incoherent scatter radar observations, and strong emphasis on forecasting and effects in addition to the core research efforts. An overview of the storm events, a description of the electronic workshop interface developed by the SPARC project for this campaign, the details of the available data sets and a summary of studies currently underway will be given.

S2-10

SPACE WEATHER EVENTS DURING THE S-RAMP SPECIAL ANALYSIS INTERVAL: APRIL – MAY 1998

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Using a wide array of datasets from International Solar Terrestrial Physics (ISTP) spacecraft, from ground-based facilities, and from operational satellites, we have found evidence of highly disturbed solar, solar wind, and geomagnetic conditions in late April and early May 1998. The combination of coronal mass ejections, solar flares, and high speed solar wind streams during this interval led to a powerful sequence of solar wind drivers of magnetospheric processes at the Earth. The result of the compounding solar wind disturbances was to produce a deep, powerful, and long-lasting enhancement of the highly relativistic electron population throughout the outer terrestrial radiation zone. There was evidence that many space weather-related spacecraft anomalies occurred during this active interval. S-RAMP has collected and organized large sets of data and images for the April-May interval. These are widely available for analysis and interpretation. The kinds of disturbances witnessed during this remarkable interval are indicative of the types of events that commonly occur during the solar maximum period. It is most important to determine how well space systems can stand up to similar multifaceted effects of the space environment over the next several years as we pass through solar maximum.

S2-11

ENERGETIC ELECTRON BEHAVIOR IN THE OUTER RADIATION ZONE DURING THE SPACE WEATHER MONTH

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The Akebono (EXOS-D) satellite made good observations of the entire radiation belts in the evening sector in the space weather month (September 1999). During the campaign we had three magnetic storms; *i.e.* September 12 – 14, 22 – 23, and 27 – 28. On early September 23, the *Dst* index reached its minimum with −160 nT, showing a major magnetic storm, while both on September 13 and 27 the decrease of the *Dst* index was very gradual, having the minimum values of −70 nT and −65 nT, respectively. Even though the *Dst* variation was big during September 22 – 23, very little enhancement of MeV electrons was observed in the outer radiation belt during the storm recovery phase. On the contrary large enhancements in the intensity of MeV electrons took place for September 12 – 14 and 27 – 28, when the *Dst* variations were rather small. These large enhancements were made due to the prolonged magnetic activities during the storm recovery phase. The Russell-McPheron effect was evident; *i.e.* the IMF was actually away for the cases of September 12 – 14 and 27 – 28. The increase in the intensity of MeV electrons was first seen in the heart of outer radiation belt and in lower energy. As time progressed the intensity of MeV electrons in far regions ($L > 5$) increased, suggesting that both an internal acceleration of the electrons and an extremely large outward diffusion are taking place in the outer radiation belt.

S2-12

EFFECTS OF IONOSPHERIC SCINTILLATION: ITS SPECIFICATION AND FORECASTING

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The ionized upper atmosphere often becomes turbulent and develops electron density irregularities. These irregularities scatter radio waves causing amplitude and phase scintillation of satellite signals. Amplitude scintillation, when intense, causes signals to fade below the noise level of the receiver. Under these circumstances, loss of signal occurs which causes communication links to encounter message errors and GPS navigation receivers to lose lock and spend additional time to reacquire the signal. Phase scintillations, imposing rapid changes in signal phase, introduce frequency fluctuations. When these fluctuations exceed the receiver bandwidth, it becomes difficult to maintain the phase lock in receivers. Scintillations are most intense in the equatorial region and occur between one hour after sunset to midnight. Scintillations in the polar region, though less intense than in the equatorial region, occur virtually at all times. At all locations, scintillations attain their maximum values during the solar maximum period. In the equatorial region, a recently developed scintillation specification system, known as the Scintillation Network Decision Aid (SCINDA), has been developed. SCINDA utilizes two geostationary satellites and performs two station measurements of scintillation and irregularity drifts. The dataset is brought to the user terminal by the internet and it drives a model to generate in near real-time three dimensional maps of scintillation structures. An equatorial satellite, Communication Navigation Outage Forecasting System (C/NOFS), has also been planned. This satellite, consisting of a multi-frequency beacon transmitter, GPS occultation sensor and a suite of in-situ sensors, that include the electric field, electron density and neutral wind sensors, is expected to specify and forecast equatorial scintillation. A possible specification and forecasting system for polar scintillation based on interplanetary magnetic field observations, and a suitably dispersed scintillation and macroscale plasma density sensors is also described.

S2-13

MAGNETIC STORM INDUCED SCINTILLATIONS AT MID-LATITUDES DURING THE SPACE WEATHER MONTHS OF SEPT/OCT 1999

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Scintillation and total electron content (TEC) observations using geostationary and GPS satellites were made from stations at $\sim$ 40 degrees N latitudes during the period Sept/Oct 1999 to study the effects of magnetic storms on communication and navigation systems. Coordinated DMSP satellite and incoherent scatter radar (ISR) data are utilized to study the background conditions associated with storm-induced TEC gradients and scintillations. Amplitude scintillations of 15 dB on 250 MHz signals from geostationary satellites and TEC fluctuations exceeding 5 TEC units (10^{16} electrons m^{-2}) per minute were observed by GPS receivers in the International Geodynamic Service (IGS) network in conjunction with background TEC gradients of $5 - 10$ TEC units per degree latitude. This impulsive onset of the stormtime component of mid-latitude scintillations is in all probability related to the direct penetration of the high latitude convection electric field into the plasmasphere. The ISR measurements from Millstone Hill have been used to determine the stormtime convection and plasma density gradients in the vicinity of the disturbed scintillation and TEC regions. Such comparisons are utilized to establish the relationship between the stormtime component of scintillations and plasma convection in the context of available models. The significance of the observed TEC fluctuations and scintillations for the Wide Area Augmentation System (WAAS), a satellite based navigation system for aircraft using GPS, is discussed.

S2-14

RELATIONSHIP OF THE APR. 29, 1998 HALO CME AND THE MAGNETIC CLOUD AND GEOACTIVITY ON MAY 2 – 3

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We discuss the solar activity that was likely associated with the magnetic cloud, extended period of anomalous solar wind signatures and moderate magnetic storm observed at Earth on May 2 – 3, 1998. At the Wind spacecraft the cloud was preceded by an interplanetary shock on May 1, 2122 UT and had a duration of $\sim$ 30 hr. It was well fit to a force-free flux rope model indicating a diameter of $\sim$ 1/2 AU, Left handedness, and with its axis pointed toward the Sun and highly inclined by 55 deg. to the ecliptic. Within the cloud and possibly extending beyond it were one or more extended periods of flows of counterstreaming electrons and both unusually cold and hot material, including an extensive amount of He^+, considered a tracer of solar filament material in solar wind ejecta. Indeed, this ejecta was likely associated with a full halo CME observed by the SOHO LASCO coronagraphs on April 29 and an M7 long-duration flare and filament eruption arcade event on the surface 0.4 solar radii southeast of Sun center. We compare measurements of the orientation, helicity/chirality, magnetic flux and speed of the solar features and the magnetic cloud to test the utility of such events for forecasting space weather effects. We also use an MHD coronal streamer and flux rope model to predict the solar wind, cloud and storm parameters.

S2-15

RAPID PROTOTYPING: APPLYING RESEARCH MODELS AND DATA TO OPERATIONAL SPACE WEATHER FORECASTING

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Advances in solar-terrestrial research are resulting in improved numerical models that can be applied to regions of space extending from the Sun to Earth. In addition to improved models, critical observations are also now available, some in near real-time, to drive and to validate the models. At the same time, available models must be carefully evaluated to determine their robustness, accuracy, and usefulness to space weather forecasting. This presentation will describe the models that are now being used operationally and those that are undergoing internal evaluation at the NOAA Space Environment Center. The various elements of the prototyping process used to evaluate model candidates and to transition selected models into operations will also be discussed. This process of model selection and transition includes: (1) model evaluation to assess the potential value to space weather operations and readiness to transition from research to operations; (2) implementation, modification, and evaluation in an operational environment; and (3) final transition to operational use. Specific operational applications of the existing models, and desired improvements to current capabilities will also be given.

S2-16

TRANSITION OF RESEARCH RESULT TO OPERATIONAL ENVIRONMENT

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Prototyping space research results to real time practical space weather applications is an important aspect of the modern space science research. More importantly, it bears on its relevance to society benefits perceived by the public. I will discuss the synergy between scientific research and applications as well as present the importance of balancing basic research activity on space weather and dedicated effort in transitioning of existing space weather products. I will describe examples that have successfully transformed research products into operational uses. The first example is the visualization of boundaries of the instantaneous auroral oval. The second example is the production of a geomagnetic disturbance index on the fly for nowcasting of space weather activity. Potential utilization of these products will also be discussed.

S2-17

THE COMMUNITY COORDINATED MODELING CENTER

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The Community Coordinated Modeling Center (CCMC) is a multi-agency partnership aimed at the creation of next generation space weather models. The goal of the CCMC is to undertake the research and developmental work necessary to substantially increase the present-day modeling capability for space weather purposes, and to provide models for transition to the rapid prototyping centers at the space weather forecast centers. This goal requires substantial research community involvement. The physical regions to be addressed by CCMC-related activities range from the solar atmosphere to the Earth's upper atmosphere. The CCMC is an integral part of NASA's Living With a Star initiative, of the National Space Weather Program Implementation Plan, and of the National Security Space Architect's Transition Plan for space weather. CCMC includes a headquarters facility at NASA Goddard Space Flight Center, as well as distributed computing facilities provided by the Air Force. In this paper we will provide updates on CCMC status, on current plans, research and development accomplishments and goals, and on the level of community involvement already underway. In particular, we will discuss recent science results obtained by CCMC models.

S2-18

THE USE OF DATA ASSIMILATION IN THE MAGNETOSPHERIC SPECIFICATION MODEL

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This paper will present recent attempts to assimilate geosynchronous particle data into the Magnetospheric Specification Model (MSM), an operational model of the inner magnetosphere that is presently being used by the Space Environment Center to provide nowcasts. The MSM calculates particle fluxes by following drifts in data-driven, time-dependent models of the electric and magnetic fields. Data assimilation can be used to improve the performance of the operational model. We will discuss and test the effectiveness of two different data assimilation techniques, direct insertion and optimization of the input. The direct-insertion method overrides the model-calculated particle fluxes with measured values, in the vicinity of the measurement. The input-optimization method adjusts model input conditions (electric and magnetic field models, plasma boundary conditions) at each time step to optimize agreement with observations.

S2-19

SUBSTORMS AND MAGNETIC STORMS FROM THE SATELLITE CHARGING PERSPECTIVE

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Substorms and magnetic storms generate significant space weather effects in the inner magnetosphere. They change the dose rates experienced by satellites in many orbits and are directly linked to the occurrence of satellite charging. Substorms inject hot plasma into the nightside magnetosphere. The drifting electron component of this hot plasma can charge the surfaces of the satellites leading to electrostatic discharges and associated satellite anomalies and sometimes failures. These occur in regions that are consistent with the expected motions of the substorm injected particles. The high energy electron enhancements associated with many magnetic storms can be sufficient to cause charging of satellite elements even behind significant shielding. Not all magnetic storms result in flux enhancements sufficient to cause such "internal" charging. Also, because the induced voltages from the "internal" charging are usually not directly measured, the anomalies they cause are more difficult to link to the space environment and the magnetic storm related space weather. However, there are a few cases in which either the anomaly statistics were sufficient to show linkage or the anomaly was reproduced by laboratory testing using energetic electron beams. Data from different satellites will be used to show the measurement of surface charging from different regions of space and link the charging to electrostatic discharges and anomalies. Similarly, we will show the magnetic storm related variability of the high energy electron fluxes and provide a look at some of the evidence that these penetrating fluxes can lead to spacecraft anomalies.

S2-20

A STATISTICAL LINK BETWEEN MAGNETIC STORMS AND SPACECRAFT ANOMALIES

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We present a statistical method to test whether there is an association between magnetic storms and spacecraft anomalies and, if so, to find what proportion of spacecraft anomalies are associated with magnetic storms. The method is a superposed epoch analysis combined with information on the known observed statistical distribution of magnetic storms and presumed statistical distribution of spacecraft anomalies. For a general database of 5033 spacecraft anomalies collected over 30 years and compiled by NOAA's National Geophysical Data Center, the results give the percentage of all spacecraft anomalies and of electrostatic discharge anomalies that are statistically associated with magnetic storms.

S2-21

MONITORING EQUIVALENT DOSES RECEIVED BY AIR CREW

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By application of an EU Directive, European air transport companies have to monitor annual equivalent doses received by air crew, starting in 2000. Calculations based on cosmic ray observation are the solution accepted by French Authorities. We will present the project, which is a typical Space Weather application.

S2-22

GROUND EFFECTS OF SPACE WEATHER

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At the Earth's surface a space weather event manifests itself as a rapid variation of the geomagnetic field. The variation induces a geoelectric field that drives "geomagnetically induced currents" (GIC) in technological systems, like electric power transmission grids, pipelines, phone cables and railway systems. In power grids, saturation of transformers may occur, which can have several harmful consequences and even result in a black-out of the whole system and in permanent damage of transformers. In pipelines, GIC are accompanied by fluctuations of the pipe-to-soil potential. This interferes with corrosion control surveys and also changes the electrochemical conditions at the pipe-soil interface enhancing possibilities of corrosion of the pipe steel. Telecommunication systems have also experienced trouble due to GIC, like overvoltages and even fires. On railways, misoperations of traffic signals have occurred. So far, Finland has not suffered from GIC problems but, due to the high-latitude location, GIC constitute a potential risk in the country. Therefore, the phenomenon is studied as a collaboration between the Finnish Meteorological Institute and the Fingrid power and Gasum pipeline companies. An active GIC research was started in Finland already more than twenty years ago. The research has contained GIC recordings, theoretical model calculations and statistical analyses of the occurrence of GIC in the Finnish systems. In a recent study, a special attention was paid to the possibility of large GIC at several 400 kV or 220 kV transformers simultaneously since such a situation is critical regarding reactive power consumption in the system. A power transmission system is a discretely-earthed network while a buried pipeline is earthed continuously through its coating, so modelling methods are quite different in these two cases.

S2-23

HIGH VOLTAGE POWER TRANSMISSION LINE DISTURBANCES DURING LARGE GEOMAGNETIC STORMS

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On March 13, 1989 a large geomagnetic storm caused extensive disruptions of high voltage power transmission circuits especially in the Quebec province of Canada but also to a lesser degree in Scandinavia. Similar events have occurred earlier a.o. during the great storms of February 8 – 9, 1986 and July 13 – 14, 1982. Some of these cases are connected to the chock-like disturbances accompanying the compression of the front of the magnetosphere by a sudden enhancement in the solar wind plasma. Other cases are related to extraordinarily intense substorm events. Using ground geomagnetic recordings it is attempted to trace the varying ionospheric current systems causing the power line failures in Scandinavia. The effects of ionospheric currents on extended conducting structures at the ground such as power transmission lines, signal lines and oil or gas pipe lines have previously been described by various models of geomagnetically induced currents (GIC). Some of these models have been applied to the storm events considered. The correspondance between model predictions and actual disturbances will be discussed as part of the presentation. Corresponding observations from the recent large magnetic storm on April 6 – 7, 2000, will also be presented.

S2-24

STUDY OF GEOELECTRIC FIELD AND GEOMAGNETICALLY INDUCED CURRENTS DURING RECENT SPACE WEATHER EVENTS

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Disturbances of the Earth's magnetic field induce electric fields and currents in the ground and in the network of power lines, pipelines and phone cables spread on the surface of the Earth. Geomagnetically induced current (GIC) data from various systems across Canada together with the geoelectric and geomagnetic field measurements were collected and analyzed for different space weather events. Geomagnetic field observations and layered earth conductivity structure were used to model the geoelectric field. The modelling results showed a good correlation with the GIC data.

We studied how the earth conductivity structure and the spatial characteristics of the magnetic field disturbance affects the accuracy of the modelling. This shows that better knowledge of the ionospheric electrojet position and therefore the spatial characteristics of geomagnetic field disturbance can improve our modelling of the geoelectric field and GIC in the ground systems.

S2-25

NOWCASTING SPACE WEATHER EFFECTS IN THE HIGH-LATITUDE IONOSPHERE WITH THE SUPERDARN HF RADARS

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The SuperDARN network of HF radars in the northern hemisphere has recently been expanded with the addition of three radars to include coverage of western Canada, Alaska, and eastern Siberia. At times, effects in the ionosphere can be observed over 2/3 of the entire high-latitude region. The convection velocity data can be synthesized into global maps of the convection pattern. These patterns portray the Space Weather within the ionospheric plasma windsand provide a useful diagnostic of the overall state of the magnetosphere-ionosphere system. Internet links to the radars make it possible to perform the analysis on the fly. In this presentation we review the activity during selected periods of intense Space Weather in SuperDARN nowcastmode. The onset and progress of disturbances are easily monitored. In addition to showing regions of intensified electric fields and currents, the various maps available at the site show the movement of auroral boundaries, the distribution of HF clutter, and the progress of HF absorption. The web page provides real-time estimates of the total cross polar cap potential variation and the effective delay time from the arrival of effects at an upstream solar wind monitor (ACE) to impact on the ionosphere. We discuss the operation of the SuperDARN nowcast facility and the application of its products to the validation and correction of predictive Space Weather services.

S2-26

A WEB-BASED EMPIRICAL MODEL OF THE EARTH'S IONOSPHERE USING INCOHERENT SCATTER RADAR DATA

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A Web-based regional empirical model of the ionosphere using incoherent scatter radar data from 1970 to the present is being developed. This model includes two parts: first, a model of basic and derived scalar parameters as measured at Millstone Hill, including electron density, electron and ion temperature, neutral meridional wind and exospheric temperature; and second, a model of the $\boldsymbol{E} \times \boldsymbol{B}$ plasma drifts and corresponding electrostatic potential patterns as obtained from measurements at Millstone Hill and the Sondrestrom facility in Greenland. The scalar model is keyed to solar and geomagnetic indices chosen by multiple regression, so that deviations of actual data from the model represent the remaining day-to-day variability due to such causes as tidal forcings, gravity waves and uncertainties in the solar EUV flux. The electric field model is keyed to the interplanetary magnetic field. It represents the average response to solar wind induced changes in the magnetospheric convection, thus providing a baseline from which more variable effects of substorms, storms and disturbed neutral winds (the disturbance dynamo) can be isolated. The combined model will be valuable in several ways to space weather studies and systems. Incoherent scatter radar data are available only a few days a month due to budgetary restrictions, but the model will always be available to provide a climatological representation of the state of the ionosphere and its variability for any set of conditions. The model covers a wide range of latitude and thus is useful for validation of global theoretical and empirical models. It will also be used in investigations of specific scientific problems, such as storm-time density gradients and enhancements. The model is available over the World Wide Web for user-specified input parameters, and a real-time version is planned.

S2-27

THE REAL TIME AMIE TECHNIQUE: HOW IT WORKS AND HOW WE CAN MAKE IT BETTER

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The real-time version of the assimilative mapping of ionospheric electrodynamics (AMIE) is a model which ingests ground-based magnetometer data which is available in near-real-time to provide a now-cast of the ionospheric electric potential, currents, and particle precipitation pattern. The model then makes a 1 hour prediction of the ionospheric state. We discribe the data gathering and processing techniques involved in this effort. In addition, we discuss the validation of the now-cast and forecast. Included in this discussion are suggestions for realistic locations for new (real-time available) ground based magnetometers which would significantly improve the specifications and forecasts provided by this model.

S2-28

THE SPACE WEATHER REQUIREMENTS FOR INDIA–A PERSPECTIVE

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India, the most populous tropical country is presently a combination of old traditions and state of the art in science and technology. While launching sophisticated satellites for communications and remote sensing, HF communications remain as the workhorse for a number of organisations in the country.In view of this, the space weather requirements listed below are at once traditional and very modern:

(1) Long term solar and Ionospheric predictions for High Frequency (HF) communications
(2) Solar cycle predictions to plan low orbiting satellite launch planning and for deciding orbital parameters
(3) Short term solar and magnetic event predictions for communications and satellite tracking
(4) Equatorial scintillation predictions to warn on satellite link degradation
(5) Intense Magnetic storm and particle event prediction to issue alerts on single event upsets at the geostationary orbit
(6) Real time indexing of geomagnetic activity to aid in Earth resources survey and in other remote sensing applications.

The present status and future plans in all the above areas will be presented.

S2-P01

ON THE RELATIONSHIP BETWEEN CORONAL MASS EJECTIONS (CMEs), INTENSIVE SOLAR FLARES, SOME MAGNETOSPHERIC PARAMETERS AND DIFFERENT TYPE AURORAS DURING GREAT MAGNETIC STORMS

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Six giant magnetic storms, with the minimum value of *Dst* variation less than −250 nT were analyzed. They are on Febr. 8 – 9, 1986; March 13 – 14, 1989; Oct. 21 – 22, 1989; March 24 – 25, 1991; Oct., 28 – 29, 1991, and Nov. 8 – 9, 1991. All of these superstorms were preceded by solar flares and, in some events, by Coronal Mass Ejections (CMEs) as well. During these superstorms, over large areas of the Earth surface, there were registered bright auroras, the luminosity spectrum of which depended on the type of heliospheric source. In some events bright green auroras occurred, whereas the A-type red ones were observed in others. Some suggestions have been made as to the nature and mechanisms of origin of similar types of luminosity. Unfortunately, data on the parameters of the solar wind generating those storms were either not available or extremely scarce. So, on the basis of the available data on temporal variations of the *Dst* index, we restored the IMP B_z component and estimated the polar cap electric voltage. Quite large values of the latter were obtained, which agrees fairly well with some direct measurements.

S2-P02

THE RELIABILITY OF PREDICTIONS OF LARGE SOLAR WIND DISTURBANCES BY AN UPSTREAM MONITOR

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Comparison of simultaneous solar wind plasma observations by several widely-separated spacecraft (INTERBALL-1, IMP 8, and WIND) has shown that the average value of their cross-correlations was about 0.7 and 15 – 20 % of cases had the very poor correlations, less than 0.5. This result means that predictions of solar wind disturbances coming to the Earth based on upstream measurements (at L1, for example) may be incorrect. We studied the dependence of the reliability of these predictions on the amplitude of solar wind disturbances and found that if we calculate the correlations for large and abrupt disturbances (for example, the increasing of the solar wind density or ion flux in 1.5 – 2 times or more during several minutes), we obtain average correlation values as large as 0.9 – 1.0.

S2-P03

GEOEFFICIENCY OF CORONAL MASS EJECTIONS DURING A RISING SOLAR CYCLE

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We have analyzed the geoefficiency of halo and partial halo coronal mass ejections (CME) observed by the SOHO/LASCO instrument during 1996 – 1999 with the exception of the second half of 1998 when the spacecraft was inoperative. This period covers most of the rising phase of cycle 23. Near the minimum most storms with $Dst < -50$ nT were driven by shocks and/or CMEs. Toward the maximum the number of disturbances due to high-speed streams increases. Furthermore, the distribution of CMEs becomes spread over a larger range of latitudes, which reduces the relative amount of earthward directed CMEs. If the observed halo or partial halo CMEs would have been used to forecast magnetospheric storms, the predictions had been much better in 1996 – 1997 but no more in 1998. The reason for this appears to be that near minimum the axes of the CMEs tend to be closer to the ecliptic plane whereas during increasing activity they can be oriented in any direction. Thus good space weather forecasting needs detailed observations of the alignment of the CME axis as well as a good prediction how far the CME axis will pass the Earth.

S2-P04

ENERGETIC ELECTRON VARIATION IN THE OUTER RADIATION ZONE DURING EARLY MAY 1998 MAGNETIC STORM

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Using NOAA and Akebono observations we examined variations of the energetic electron flux in the outer radiation zone during May 2 and 4, 1998 magnetic storm, which was two-step storm. Both a flux dropout and an inward shift of the outer belt MeV electrons were recorded during the main phase of May 2 magnetic storm. A very big injection of the intermediate energy (30 keV –100 keV) electrons to the heart of the outer radiation zone took place during the main phase of the storm. During the recovery phase of the storm an increase in the MeV electron flux was seen, which surpassed the pre-storm level in one day. Comparison of NOAA and Akebono observations yields that the injected electrons with energy of 100 keV seeded a subsequent enhancement of the MeV electrons in the outer radiation zone. A more inward shift of the peak position as well as a flux dropout occurred during the main phase of the May 4 magnetic storm. No significant injection of the intermediate energy (30 keV –100 keV) electrons was, however, seen during the main phase of the May 4 magnetic storm. A remarkable increase of the MeV electron flux was seen during the recovery phase of the storm. The pre-existing intermediate electrons seeded the increase of the MeV electrons near the new peak portion. The increase propagated to higher L region with a significant time delay, suggesting an enhanced radial diffusion.

S2-P05

ENHANCEMENTS OF ENERGETIC ELECTRON FLUX AT GEOSYNCHRONOUS ORBIT DURING THE RECOVERY PHASE OF GEOMAGNETIC STORM: IMPORTANCE OF THE SUBSTORM ACTIVITY HISTORY

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Relativistic (> 2 MeV) electron flux at geosynchronous orbit(GSO) enhances during the recovery phase of geomagnetic storm after its rapid diminishment in the main phase, and this enhancement often exceeds the pre-storm level. In this study we demonstrate that this electron flux enhancement during the recovery phase is strongly associated with the history of substorm activity represented by ΣAL, where Σ denotes the summation from the time of a Dst minimum peak. We used electron flux data that were obtained with Space Environment Monitor onboard Geostationary Meteorological Satellite. Our approach is to model the temporal variations of the electron flux with the technique of Elman artificial neural network (ANN). The recent history of AL, ΣAL, Dst, ΣDst, and time from the Dst minimum were used as initial input parameters, and the ANN was trained using the data with 1043 hours of 9 typical storms. The performance of the model was evaluated by comparing output electron fluxes with one-hour ahead observations for 20 storm events that were selected from the period of 1978 – 1994. The best prediction is identified at Oct. 5 – 9, 1985 storm for which the correlation coefficient is 0.95, and the prediction efficiency reaches 80. The average of the correlation coefficient for the 20 cases is 0.84, the prediction efficiency 71, and the rms error of the network 0.47 It is found that these high evaluation marks are obtained only when ΣAL is included in the input parameters.

S2-P06

FORMATION OF NEW PROTON RADIATION BELT ASSOCIATED WITH SOLAR PROTON EVENTS AND INTERPLANETARY SHOCKS

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It was revealed that a formation of a new proton radiation belt is closely associated with solar energetic protons and an interplanetary shock passage. A solar proton event was detected by GOES satellite at 14:20 UT on May 2, 1998 and the flux (6.3 MeV–15 MeV) enhancement appeared in region around $L = 4.5$ in the data of Akebono satellite at 17:25 UT on May 2. The Akebono also observed the increase in the higher energy (15 MeV–29 MeV, 29 MeV–62 MeV) proton flux there at 20:27 UT, which indicates the penetration of the energetic protons to near Earth region. The ACE satellite detected multiple interplanetary shock passages from Apr 30 to May 4, and two major magnetic storms occurred during that period. Solar proton event was on going during the first magnetic storm and a strong interplanetary shock hit the geomagnetic field. A new proton radiation belt was formed in the region around $L = 3.0$ due to this shock. This phenomenon indicates that SEPs are source population of the new proton radiation belt, and the interplanetary shock and a strong compression of the Earth's geomagnetic field play an important role in the formation of the new proton radiation belt. This radiation belt persisted for several months, causing significant bad effects on spacecraft and astronauts.

S2-P07

RADIAL DEPENDENCE OF RELATIVISTIC ELECTRON FLUXES DURING THE STORM MAIN PHASE

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Satellite observations have revealed that the flux variations of outer belt relativistic electrons during the main phase of magnetic storms exhibit a strong radial dependence. This dependency on L can be characterized as small increases or decreases at the inner edge of the belt ($L \sim 2.5 - 3.5$) and a large decrease in its outer region ($L \sim 5 - 6$). In this work, we extend the study by *Kim and Chan* [1997] of relativistic electron flux decreases at geostationary orbit and investigate the characteristic radial dependence in terms of the fully adiabatic response of relativistic electrons to magnetic field perturbations. We calculate storm time fluxes of equatorially mirroring electrons by adiabatically evolving the prestorm values using Liouville's theorem and the conservation of the first and third adiabatic invariants. Calculations of fully adiabatic fluxes successfully reproduce the radial variation of relativistic electron fluxes during the storm main phase. It is the radial structure of magnetic field perturbations and the spatial and energy dependence of the quiet time electron distribution that affect the main phase fluxes in an adiabatic process. In response to the field perturbations, adiabatic flux changes become larger at larger L shells where electrons experience strong deceleration and large radial displacement. The slight increase of the inner edge electron flux can be attributed to the non-monotonic energy spectrum of the quiet time electron distribution. The increasing electron flux with energy can yield a flux increase even during adiabatic deceleration. We conclude that a fully adiabatic treatment can explain the observed variation of relativistic electron fluxes across the outer radiation belt during the storm main phase.

S2-P08

MAGNETIC FIELD VARIATIONS AT GEOSYNCHRONOUS ORBIT AND ITS RELATIONS TO RELATIVISTIC ELECTRON FLUX

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Magnetic field variations at geosynchronous orbit can give us information of magnetospheric current systems, Since magnetic field variations at geosynchronous orbit are caused by magnetospheric current systems including magnetopause currents, ring currents, cross tail currents, and field-aligned currents. We have statistically examined dynamic pressure, pressure-corrected Dst, and dipole tilt angle dependence of magnetic field variations at geosynchronous orbit with using 1-hour averaged magnetic field data obtained from GOES-8, 9, and 10. The results of our data analysis suggest that the contribution from tail currents is significant in the midnight sector and the tail current region seems to approach geosynchronous orbit during the large storm while the contribution from ring currents and magnetopause currents are significant in the noon sector. On the contrary, current relativistic electron flux is one of the important information for satellite operation. However, observations of relativistic electron flux are not fully covered at whole longitude of geosynchronous orbit. Therefore some assimilative technique is needed for estimating flux at whole orbit. For this point of view, we start studying the relationships between magnetic field and relativistic electron flux using the results of our statistical data analysis. Because L-shell value is changing depending on local time and magnetic activity due to magnetic field variations. The result of our study and possibility for estimating relativistic electron flux at geosynchronous orbit will be presented.

S2-P09

MULTI-SATELLITE OBSERVATIONS OF GEOSYNCHRONOUS MAGNETOPAUSE CROSSINGS

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The magnetopause sometimes moves across the geosynchronous orbit. These events are called Geosynchronous Magnetopause Crossings (GMCs). Here we show 3 case studies of GMC events. The first event occurred on February 8, 1986. The magnetopause moving earthward was observed first by AMPTE/CCE satellite at 1433 UT around 8.2 R_E and 10 LT and 5 min later by GOES-5 around 6.6 R_E and 9.5 LT. The magnetic field increased both at the geosynchronous orbit and on the ground suggesting effect of the solar wind dynamic pressure. In the second event which occurred 2013–2326 UT also on February 8, 1986, the bow shock was observed at 7.5 R_E by AMPTE/CCE, and a magnetopause crossing was observed at 5.2 R_E by AMPTE/CCE. The average velocity of the inward motion was about 30 – 40 km/sec. The third GMC event occurred on March 10, 1998. GOES-9 located in the morning side (9h LT) went out into the magnetosheath from 1754 to 1807 UT but GOES-8 around noon (13h LT) stayed in the magnetosphere. The IMF-B_z took a large negative value (-15 nT) and the SYM index decreased to -110 nT. Since the solar wind dynamic pressure was not so high (about 5 nPa), magnetic erosion may be a main cause of this GMC.

S2-P10

CHANNELS OF INFLUENCE OF THE SHORT-TERM CHANGES IN SOLAR ACTIVITY ON STATE OF THE LOWER ATMOSPHERE

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Analysis of long standing measurements of atmospheric perturbations in the Arctic and Antarctic regions has revealed that the polar lower atmosphere is affected by fluctuations of solar and galactic cosmic rays, changes in the solar wind pressure and variations of the interplanetary magnetic field (IMF). The cosmic rays variations crucially influence temperature and pressure regimes above the Antarctic plateau and can dramatically change the wind system above Antarctica. Changes in the UV irradiation have been found in connection with such manifestations of solar activity as the active regions, solar proton events, and passage of regions responsible for the Forbush decrease. It is significant that UV-irradiance starts to increase 5 – 7 days before the key day of solar proton events (SPE) or Forbush decrease, that can explain ahead reaction of the lower atmosphere to the Forbush decrease and SPE. Finding of the quasi-biennial periodicity in level of the solar UV irradiance implies that just change in solar UV radiation specifies the west or east direction of zonal winds in the Earth's equatorial stratosphere (*i.e.*, well-known quasi-biennial oscillations-QBO). Temperature and circulation regimes in the lower stratosphere are also crucially affected by the location of the magnetopause, *i.e.*, by the solar wind pressure. The IMF parameters determine the electric potential patterns in the polar region and,influence, correspondingly, the global electric circuit generated by tropical thunderstorms. These four channels act simultaneously and inconsistently; mechanisms of their acion remain unclear.

S2-P11

ON NONLINEARITY FEATURES OF THE CLIMATE SYSTEM

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The issues of the Sun-climate connections attract the interest within the global change studies. To solve global problems an application of global approaches implying the consideration of as complete set of forcing factors as possible is required. To infer the patterns of the climate system response in a more reliable manner the plausible space weather signatures in the meteorological parameter changes are analysed. For this purpose the available time series of air temperature and indices of solar and/or geomagnetic activity on a daily value basis are used as input data for nonlinear analysis to reveal specific features of the climate system dynamical behaviour. The results obtained are discussed from the viewpoint of the nonlinear characteristics derived.

S2-P12

NEW PROSPECTS IN PATTERN RECOGNITION OF SPACE WEATHER CONDITIONS

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The Earth's magnetosphere exhibits considerable spatial changes and large temporal fluctuations within a wide range of scales which are directly related to the conditions present in the solar – terrestrial system. In order to contribute to the understanding of solar wind – magnetosphere interactions linear and nonlinear techniques will be used in the paper. The scaling and singularity properties of the field fluctuations will be modeled by multifractals. Simultaneously, multivariate statistics and neural networks representing powerful pattern – recognition techniques for an improved classification of space weather conditions will be also applied.

S2-P13

DIURNAL VARIATION OF GEOMAGNETIC ACTIVITY AND ITS ROLE IN SPACE WEATHER FORECAST

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We calculated the diurnal variations both in the occurrence of large AE indices and in the AO index. Both methods show similar diurnal variations in geomagnetic activity with a deep minimum around $(3-7)$ UT in winter and equinoctial months. In winter months, the probability of high geomagnetic activity versus UT varies by as much as a factor of 3, and in equinoctial months it can vary by a factor of 1.5. The observed UT variation is consistent with earlier results of other scientists, but it is very different from that expected from mechanisms proposed earlier to explain the seasonal variation. The existence of the diurnal variation in geomagnetic activity shows that some UT sectors are more or less favorable to the development of geomagnetic disturbances than other UT sectors. We calculated correlation patterns for the AE index versus solar wind parameters inside and outside the $(02-07)$ UT sector related to the minimum in geomagnetic activity. The correlation patterns appear indeed different in these two sectors. It shows that it is possible to improve significantly the reliability of Space Weather forecast by taking into account the dependence of geomagnetic activity not only on solar wind parameters but also on universal time and season. Our test shows that a simple account for the dependence of geomagnetic activity on universal time can improve the reliability of Space Weather forecasting by at least two times in the $(02-07)$ UT sector.

S2-P14

NEAR-REAL TIME Kp ESTIMATES

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The existing Kp index is the result of an effort to quantify geomagnetic disturbances in a simple manner. The index is derived from magnetic field data acquired at 13 ground stations distributed worldwide at moderately high latitudes $(49-62$ degrees). Kp is widely used to empirically specify the location of the cusp, plasmapause, and other plasma regions/boundaries, and also as input to various models of the magnetosphere and ionosphere. The official Kp index is delivered with a delay of many days so it is not useful for near-real time monitoring of the state of the magnetosphere. For operational purposes, one could obtain Kp estimates with much smaller delay using data available in near-real time from some stations. However, there are problems with the estimates: (1) the magnetometer data contain spikes and other anomalies and these need to be removed; (2) there is no clear definition of the quiet day curve that gives the baseline for the magnetic field perturbation at each station; (3) longitudinal distribution of the stations is not the same as those for the official Kp. In this paper we present a practical procedure to handle these problems. Specifically, we describe a data-adaptive data cleaning procedure, an automated procedure to define the quiet day curve, and a method to relate the magnetic field perturbation to the K index for individual stations. Test runs of our algorithm using data from 9 INTERMAGNET stations indicate that the correlation coefficient between the estimated and official Kp is higher than 0.9 with a standard error of approximately 0.5 (in Kp unit).

S2-P15

SPACE ENVIRONMENT SIMULATOR FOR THE RESEARCH OF THE SPACECRAFT-PLASMA INTERACTIONS

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One of the important issues to be studied in the space weather research is the influence of the solar activity variation to the spacecraft environment. In order to investigate the spacecraft-plasma interactions, we would like to propose the space environment simulator which enables us to perform large-scaled numerical simulations of the PIC (Particle-In-Cell) model. Since the simulator can solve the spatial and temporal evolution of the electromagnetic fields and plasma dynamics in the self-consistent manner, we can examine the physical process of the spacecraft-environment interactions including kinetic effects such as charging/discharging at the surface, plasma and field responses not only in the steady state but also in the transient state. A prototype of this simulator is planned to be installed as one of the components of the space simulation net laboratory. This net laboratory is now being developed and will enable us to perform numerical simulations through the network by providing the plasma environment of interest as the initial and boundary conditions. In the presentation, in addition to the concept of the simulator and the net simulation laboratory, we will present some results of the simulations associated with the spacecraft-plasma interactions such as observed in the electrodynamic tethered satellite experiments.

S2-P16

THE STUDY OF IONOSPHERIC RESPONSE TO SOLAR FLARE OCCURRED ON NOV. 22, 1998 WITH GPS METHOD

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Ionospheric disturbances have been widely studied using dual-frequency GPS receivers. With the method a lot of results have been obtained in recent years. It is known that large solar flare can cause an ionospheric TEC enhancement, but the relation between them has not been fully established. Besides, since compared with the background TEC, the increase due to flare effect in general takes only a small percentage, there need a proper method to distinguish the effect. In this paper, a method is put forward to minimize the effect of noises so that small TEC changes caused by flares can be recognized(to a certain degree). Using data from 4 dual-frequency GPS receivers distributed over China, the temporal TEC variations of the ionosphere during the solar flare occurred on Nov 22, 1998 are calculated. The X-ray level of the flare is X3.7. The results indicate that an obvious TEC enhancements in the ionosphere does occur during the flare, the largest value of the TEC enhancement caused by this flare is about 1.25 TECU. Discussions on the features and validity of this method in studying such ionospheric disturbances are made in some detail in the end of this paper. It is concluded that this method has advantages over some traditional methods in the study of the ionospheric disturbances caused by solar flares and it can be used in analyzing the global ionospheric disturbance evolution using the data from GPS receivers scattered all over the world.

S2-P17

RECENT OBSERVATIONS AND MODELING OF THE FORMATION OF POLAR CAP PATCHES

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Two campaigns aimed to measure plasma densities and electric fields in the regions where polar cap patches are formed were conducted at very high latitudes. The first campaign was performed on February 1996 and included simultaneous operations of the Sondrestrom and the EISCAT incoherent scatter radars. The second campaign was carried out on January 1999 and comprised the Sondrestrom and Svalbard radars. On both occasions the SuperDARN network of coherent radars observed the convection pattern in a large part of the auroral oval polar cap region. During the first campaign two different types of events were seen. In both events the Sondrestrom radar registered the formation and evolution of large-scale density structures. The first event consisted of the passage of traveling convection vortices, and the other event occurred in association with the development of large plasma jets (LPJ) embedded in the sunward convection part of the dusk cell. It was observed that on both types of events a section of the plasma density was eroded by a factor of 2. The measurements suggest that the number density reduction is caused by an enhancement in the O^+ recombination due to en elevated Ti which was produced by the much higher frictional heating inside the vortices or within the plasma jets. The data also provide evidence for abrupt changes in the location of the LPJ that creates regions containing dayside plasma almost detached from the rest of the oval density. Numerical simulations of the role of LPJ on producing density depletions indicate that transport of low-density plasma from earlier (or much later) local times can contribute to $\sim$60 % of the depletion.

S2-P18

AURORAL ZONE GPS TEC MEASUREMENTS AND IONOSPHERIC BACKSCATTER FROM SUPERDARN

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The dispersive and highly structured ionosphere can limit the accuracy of positions determined by Global Positioning System (GPS) satellite navigation systems and even result in a loss of carrier lock and intermittent GPS receiver operation. The auroral ionosphere is subject to space weather which can cause significant spatial and temporal variations of electron density and density gradients resulting in highly variable total electron content (TEC) and radio scintillation. Remote sensing of the ionospheric irregularities and their drift motions by SuperDARN provides maps of ionospheric HF backscatter. The ionospheric structure is thus characterized near the GPS line-of-sight ionospheric pierce point for GPS ground receivers measuring TEC. Some preliminary results from analysis of the two kind of data collected during a storm event will be presented.

S2-P19

SPACE WEATHER PRODUCTS FROM SUPERDARN

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SuperDARN provides near-continuous radar coverage of much of the high-latitude ionosphere and offers an excellent means of monitoring the auroral zone and polar cap. For the past two years, data from the northern-hemisphere radars of this network have been used to provide global views of high-latitude plasma convection as well as real-time determinations of the polar-cap potential drop. The quantities have appeared on the JHU/APL SuperDARN web site in near real-time and with two-minute temporal resolution. In this presentation, we consider other space-weather parameters that might be defined from the SuperDARN observations. In particular, recent studies have indicated that the equatorward boundary of backscatter observed with the radars is closely associated with the equatorward boundary of auroral precipitation. This boundary can also be associated with the equatorward boundary of high-latitude radar clutter and the equatorward boundary of the high-latitude scintillation zone. The flow reversal boundary in the convection maps is closely related to the poleward boundary of auroral precipitation (effectively the polar cap boundary). Thus, the SuperDARN radars provide a continuous identification of both the auroral zone and polar cap, in addition to a determination of the convection pattern. Using the SuperDARN receivers as riometers and combining data from them with data from high-latitude riometer networks, we have found that we can provide a global specification of the structure and dynamics of high-latitude absorption. Finally, intercomparison of the operating frequencies and backscatter characteristics of the various radars provides a real-time diagnostic of high-latitude propagation conditions. In this presentation, we will present examples of these various capabilities.

S2-P20

STATISTICAL INVESTIGATION OF THE SATURATION EFFECT IN THE IONOSPHERIC *FOF*$_2$ VERSUS SUNSPOTS, SOLAR RADIO NOISE, AND SOLAR EUV

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This study explores the possible saturation effects in the ionospheric foF_2 due to smoothed sunspot number $R12$, smoothed solar radio noise (10.7 cm) flux $F(10.7)$, and smoothed solar EUV. To locate the $R12$, $F(10.7)$ or EUV value at which the foF_2 values are saturated, a two-segmented regression model is built based on the data of the strictly rise period of the 21st solar cycle recorded by eight ionosonde stations scattering roughly between 40°N and 40°S geomagnetic latitude. The regression model is then fitted into the foF_2 data observed at Chung-Li station to investigate the hourly variation of the saturation effect. To check the solar cycle variation of the saturation effect, the same model is further built based on the foF_2 data observed at Chung-Li station in the rise period of the 22nd solar cycle. Results show that clear saturation features appear around the equatorial anomaly crest region.

S2-P21

CONTINUOUS MONITORING AND FORECASTING OF SPACE WEATHER BY USING ON-LINE COSMIC RAY DATA FROM THE WORLD NETWORK OF STATIONS

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The main idea of International Cosmic Ray Service (ICRS) is to use on-line cosmic ray data from many stations of the existing world-wide network. In many investigations of historical events it was shown that by cosmic rays it is possible to obtain very important information on the space weather and dynamic processes in the Heliosphere. Moreover, we show that ground-based cosmic ray data (exchanged in real time in the frame of ICRS), can be effectively used for obtaining continuous information on the electromagnetic and radiation situation in the interplanetary space and in the Earth's magnetosphere, for forecasting of great geomagnetic storms associated with Forbush-decreases, for prediction of big increases of radiation hazard and other dangerous phenomena. We show that ICRS can predict also extremely big increases of radiation hazards very dangerous for the Earth's civilization due to extremely powerful solar flares and local supernova explosions. In the frame of ICRS, after some additional investigations of high energy cosmic-ray distribution function outside the Heliosphere, it could be possible in future to solve more complicated problems: to determine in combination with astrophysical methods the location and velocity of nearest dust-molecular galactic clouds with frozen-in magnetic fields and predict the expected time of the Sun capturing by some clouds with possible great global changes of Earth's climate.

S2-P22

SPACE WEATHER IMPACTS ON THE EARTH: INCREASING OF THE FREQUENCY OF MYOCARDIAL INFARCTIONS, BRAIN STROKES AND TRAFFIC ACCIDENTS IN MOSCOW AND IN ST. PETERSBURG IN PERIODS OF SPACE MAGNETIC STORMS ASSOCIATED WITH COSMIC RAY FORBUSH-DECREASES

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On the basis of a great amount of medical information obtained in Moscow and St. Petersburg we show that cosmic ray Forbush-decreases can be considered as important indicators of space weather dangerous phenomena regarding their impact on the Earth. We analyzed 6304000 ambulance cases in Moscow for 1979 – 1981 (among them 85819 myocardial infarctions and 98625 brain strokes), 1314200 ambulance cases in St. Petersburg for 1981 (among them 14248 myocardial infarctions), 17005 heavy traffic accident cases in St. Petersburg for 1987 – 1989, and 15543 myocardial infarctions in hospitals of St. Petersburg in 1989 – 1990. We found that, regarding terrestrial impacts, it is important only the decreasing phase of cosmic ray Forbush-decreases (one-two days after the sudden commencement of geomagnetic storm). In these periods the frequency of myocardial infarctions increased in average by 12.5 ± 1.5 % in Moscow and by 14.0 ± 5.5 % in St. Petersburg, the frequency of brain strokes increased by 7.0 ± 1.7 % in Moscow and frequency of traffic accidents (with emergency service) increased by 17.4 ± 3.1 % in St. Petersburg. The forecasting of space phenomena causing terrestrial impacts and cosmic ray Forbush-decreases can be done by

on-line data, precursory effects, changes in the 3-D cosmic ray anisotropy and changes in the cosmic ray spectrum of scintillations before the sudden commencement of geomagnetic storm.

S2-P23

LIGHTNING – AN INDEX OF SPACE WEATHER DIAGNOSTICS

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Solar radiations play an important role in controlling the space weather. The cloud formation, their movements and charge separation are known to result into lighting phenomena. The lighting phenomena has played a dominant role in the diagnostics of earth's lower and upper atmosphere. Initially the phenomena of lighting was thought to be arising from lower lying clouds which is known to move upwards as well as downwards. However, the diagnostic measurements were primarily confined to lighting radiations from cloud-to-ground (CG) discharges. In recent years, extensive study of lighting generated electromagnetic waves and their propagation have been carried out. It is now established that CG and cloud-to-cloud (CC) lighting discharges depict almost equal probability despite their dominantly different radiated electromagnetic wave power and associated polar distribution in space. The EM-waves propagate upwards undergoing multiple reflections between earth-ionosphere wave guide. The higher frequency components propagate outward and are monitored by space-borne devices. The variational features of CG and CC discharges are known to provide important details of ionized regions. Some of these details are being worked. However, it seems that we have spent more time in projecting nomenclature of some of these phenomena and the in-depth study of electromagnetic radiations and their propagation features are not yet fully developed. Some of these features are developed and discussed in detail.

S3-01

A REVIEW OF CORONAL MASS EJECTION OBSERVATIONS FROM WHITE LIGHT CORONAGRAPH INSTRUMENTS

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Coronal Mass Ejections (CMEs) are large scale dynamic events in which plasma that was initially contained on closed magnetic field lines is ejected into interplanetary space. These events are daily occurrances (as averaged over a solar cycle) and involve significant masses, typically 10^{15} to 10^{16} grams of coronal and chromospheric material, and mechanical energies of order 10^{31} to 10^{32} ergs. CMEs have been observed primarily in white light images of the corona recorded by spaceborne coronagraphs and ground based coronameters for over a quarter of a century. Basic properties of CMEs have been measured and catalogued. Statistical studies have been undertaken to determine the relationship between CMEs and other forms of solar activity in an effort to identify and understand the underlying physical mechanisms responsible for their formation. Although there is no consensus on the exact causes of these events there is general agreement on a number of points. General properties of CMEs and their assocations to other forms of solar activity will be reviewed including recent observations and findings from instruments on the Solar and Heliospheric Observatory (SOHO).

S3-02

SIGMOIDAL MORPHOLOGY AS A CME PREDICTOR

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In the last several years, much attention has been given to S- or reverse-S shaped structures in the solar corona. These features, described as "sigmoidal" by *Rust and Kumar* (*Sol. Phys.*, **155**, 69, 1994), are signatures of the twisted magnetic field in the solar atmosphere. Various observational and statistical studies have demonstrated a correlation between sigmoidal morphology and the likelihood that a given magnetic structure will erupt in an ejection of material from the corona. Such a correlation might play an important role in a tool for predicting eruptive events in the solar atmosphere. Similarly, theoretical and numerical models have begun to demonstrate the connection between the appearance of a sigmoidal shape in a structure and the helicity of the associated magnetic field. We will review the major findings (to date) related to solar sigmoid structures, and describe the directions that present research is taking; the possibility of using the sigmoidal appearance within a tool for predicting CMEs will be discussed.

S3-03

OBSERVATIONS OF THE SOURCE REGIONS OF CORONAL MASS EJECTIONS

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Coronal mass ejections (CMEs) that occur on the solar disk are often observed as 'halo' events in coronagraph images. Halo CMEs are important as drivers of space weather phenomena. They are also important for understanding of CMEs in general, as the source regions of halo events are often well situated for study with telescopes that image the low corona on the solar disk. It is usually more difficult to study the source regions of CMEs that occur near the solar limb. In this paper, we present results from a study of the source regions of CMEs observed with the EIT and LASCO experiments on SOHO. We will focus on the following questions:
1) What are the observed signatures of CMEs in EUV images of the corona?
2) How do the manifestations of CME activity near the solar surface relate to the observed properties of CMEs at larger distances from the Sun?
3) What is the underlying magnetic structure of a 'typical' CME source region?

S3-04

ERUPTIVE FLARES AND CMEs

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The relation between flares and coronal mass ejections (CMEs) continues to be a hot topic, even though we are aware that a CME could be observed without an associated X-ray brightening as intense as a flare. For limb flares, we have shown that those with hot plasma ejections as observed with the Yohkoh Soft X-ray Telescope (SXT) tend to be associated with CME, as observed with the Large-Angle Spectroscopic Coronagraph (LASCO) on board the Solar and Heliospheric Observatory (SOHO). These "eruptive" flares are not necessarily long duration events. Recently, we have analyzed more data for flare/CME events, including those that occurred on disk. Based on the analyses, we discuss such questions as: What part of a CME do the X-ray flare ejecta represent? Is the CME energy correlated with the flare energy? How coordinated is the energy release at different heights of the corona? Can both the CME and flare be triggered by a single mechanism?

S3-05

LASCO AND EIT OBSERVATIONS OF CORONAL MASS EJECTIONS

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A set of 32 coronal mass ejections observed with the LASCO and EIT instruments on SOHO have been examined. These events have been selected from the period between May 1997 through May 1998 and includes the period of solar minimum and the rise of solar cycle 23. The criteria for including these events were that they were observed as a CME in LASCO, they were well observed with EIT and they were located near disk center. The sources of these 32 events were active regions without filaments (26 cases),active regions with filaments (7 cases) and quiescent filaments (6 cases). In the EIT, the signature of the initiation of the coronal mass ejection includes flares, EIT waves, coronal dimmings and mass ejections. The characteristics of the photospheric magnetic activity associated with these events, observed with NSO/Kitt Peak and MDI/SOHO magnetograms, indicate that CMEs are associated with a wide range of activity that includes small scale flux emergence and cancellation, large scale flux emergence, and large scale flux decay. During this period of the solar cycle, the solar disk contains few active regions which are generally generally short lives so that there may be a solar cycle dependence to these conclusions.

S3-06

EVOLUTION OF CME-PRODUCTIVE ACTIVE REGIONS AND SWITCHBACKS

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The types of flare-productive active regions are well known. However, it is less clear which types of active regions are the most CME-productive ones. Flares and CMEs do not occur randomly. They both have their specific place and role in the evolution of their source region and its magnetic environment. Confined flares dissipate local magnetic stresses, while they leave the helicity unchanged. CMEs are the means by which the accumulated flux and twist (helicity) can be shed by the Sun as was proposed by *Low* (*Solar Phys.* **167**, 217, 1996) and recently shown by *Bleybel et al.* (*ESA SP-448*, 901, 1999). The presence of large-scale twist in an active region appears to be a necessary condition for its CME activity. Active regions which are created by twisted flux emergence are obvious candidates for being CME-productive. However, even in active regions with no initial twist, a combined effect of the differential rotation, meridional flow and magnetic diffusion acting on initially north-south oriented magnetic inversion lines, can produce axial fields consistent with the observed hemispheric chirality pattern and can form so-called switchback inversion lines, which were found CME-productive (*van Ballegooijen et al.*, *ApJ*, **501**, 866, 1998; *McAllister and Crooker*, *AGU GMS*, **279**, 1997). An analysis of the long-term magnetic evolution and CME activity of an isolated active region with a switchback inversion line indicates the sustained CME production level of decaying active regions indeed (*van Driel-Gesztelyi et al.*, *ASP CS*, **184**, 291, 1999). Case-studies of individual CME events provide valuable clues for understanding the role of the switchbacks in the CME initiation process and productivity (*van Driel-Gesztelyi et al.*, *ASP CS*, **150**, 358, 1998; *Plunkett et al.*, *ASP CS*, **150**, 475).

S3-07

EMERGING FLUX TRIGGER MECHANISM FOR CORONAL MASS EJECTIONS

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Observations indicate the reconnection-favored emerging flux has a strong correlation with coronal mass ejections (CMEs). Motivated by this observed correlation, an emerging flux trigger mechanism is proposed for the onset of CMEs, for the onset of CMEs, using two-dimensional magnetohydrodynamic (MHD) numerical simulations: When an emerging flux appears within the filament channel, it cancels the magnetic field below the flux rope or reconnects with the two-sided ambient field lines, leading to the rise of the flux rope (due to loss of equilibrium) and the current sheet formation below it. Similar global restructuring and resulting rise motion of the flux rope occurs also when an emerging flux appears on the outer edge of the filament channel. In either case, fast magnetic reconnection (in the current sheet below the flux rope) is necessary to induce fast ejection of the flux rope (*i.e.*, CME). It has also been shown that the reconnection-unfavored emerging flux makes the flux rope move down. These simulations explain the observed correlation between CMEs and reconnection-favored emerging flux.

S3-08

SOLAR ERUPTIONS SEEN IN SOFT X-RAYS

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The immediate cause of a CME is in the eruption of material from the solar corona. We now have many observations from Yohkoh, SOHO, and TRACE of the structures involved in solar eruptions – eruptive flares, quiet-Sun arcade events, and more global structures. This paper presents some of these observations and discusses the manner in which new field lines may change from closed to open configurations.

S3-09

LONG WAVELENGTH RADIO BURSTS ASSOCIATED WITH CMEs NEAR THE SUN

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The Radio and Plasma Wave experiment (WAVES) on board the Wind mission has bridged the gap between coronal and interplanetary observations of shock waves. The WAVES/RAD2 receiver of records radio bursts in the decameter-hectometric (DH) wavelength regime ($14 - 1$ MHz) corresponding to a coronal height of $2 - 5$ solar radii. A number of different types of radio bursts known in the metric domain are also observed in the DH domain, but some of them start only in the DH domain. Type II bursts (due to CME-driven shocks) and SA events (due to energetic electrons escaping from the shock) are two important classes of radio emission closely associated with CMEs. We describe several examples of these bursts and discuss their importance in undertanding these radio bursts in understanding the propagation of CMEs.

S3-10

PROMINENCE AND CORONAL MAGNETIC FIELD SYSTEMS BEFORE AND DURING CORONAL MASS EJECTIONS

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In prominences (filaments) and their surrounding coronal arcades, plasma flows are field-aligned. Therefore, combined observations of the plasma structure, plasma flows, and photospheric footpoint magnetic polarities of filaments, and their overlying coronal arcades, reveal the directions of the magnetic fields in them. With the addition of perspective information enabled by observations of a filament and its overlying coronal arcade from one or more successive days as the Sun rotates, enough information is available to construct empirical models of the overall 3-dimensional configuration of their magnetic fields. Examples of such empirical models, show that prominences (called filaments when observed against the disk) and their surrounding coronal arcades are different and separate magnetic field structures above the photosphere. Their identities as separate magnetic structures are consistent with their large differences in temperture and density and the existence of a void or "cavity" between them.

While the magnetic fields of prominences and their surrounding coronal magnetic fields are spatially separate, interrelationships are shown by their (1) proportionality in height, (2) simultaneity of eruption, and (3) opposite chiralities. Consideration of how prominences and coronal arcades are initially released from their chromopsheric rooting has led to a single mechanism for both – magnetic reconnection between the nearest upward and downward fields in the loops of the arcade and reconnection between the nearest upward and downward fields in the barbs (caterpillar-like legs) of the prominence. Because a prominence and its overlying coronal arcade initially have opposite chirality, their respective reconnection processes during eruption introduce helical structure of opposite sign in each. The respective timing of the reconnection in each results in the encasing of the main body of the erupting prominence within the erupting "coronal mass ejection".

S3-11

THE RELATIONSHIP BETWEEN CMEs AND PROMINENCE ERUPTIONS FROM SOHO AND TENERIFE OBSERVATIONS

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From multi-wavelength studies of eruptions of prominences observed by Yohkoh, SoHO and ground-based observatories, we find a good correlation between prominence eruptions and CMEs (*i.e.*, May 1 1996, Sept 25 1996, May 31 1997). In several cases, nevertheless, the CME is initiated before the eruption.

We are able to explain the different CMEs by the different processesses which could initiate the destabilization. Numerical magnetohydrodynamic simulation models developed by S. T. Wu show that two distinct CME initiation processes can be observed:

1. magnetic field emergence
2. photospheric shear

These processes are flux rope driven. The energy is stored in the flux rope. The events which showed that the CME was launched prior to the flux rope eruption is modelled by shear-induced loss of equilibrium. The magnetic configuration in the corona should involve the initial presence of a twisted flux tube. The eruption could be driven by a fast increase of the poloidal field in the flux tube or by photospheric shearing motions of the flux tube.

S3-12

A NEW THEORY OF CORONAL MASS EJECTIONS AND MAGNETIC CLOUDS

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The prevailing framework of understanding coronal mass ejections (CMEs) is the hypothesis that the quasi-static changes in the photospheric magnetic field increase the magnetic energy in the corona. However, this hypothesis has yet to yield a quantitative model of CMEs and their heliospheric consequences. Recently, a new theory has been proposed to describe the physics of CMEs. This theory posits that the initial structure is a magnetic flux rope that is ultimately connected to the solar dynamo in the convection zone and that the flux rope erupts in response to the increased magnetic energy that has propagated up from the source. Specifically, poloidal flux is "injected" into the flux rope and the subsequent dynamics are computed. A series of systematic comparisons of theoretical results with observations have been carried out. The results show that the new theory is able to correctly describe the observed dynamics of a significant class of CMEs ("flux rope" CMEs) and observed magnetic clouds (MCs), the presumed evolutionary end products of CMEs. We discuss the model and comparison with LASCO, EIT, and solar wind data. The apparent good agreement with observations shows that CMEs can be understood as the coronal response to the magnetic energy that propagates up from the dynamo. The model results indicate that the propagation process is everywhere Alfvénic (including the photosphere). Obervational signatures to test the new theory are discussed, including the photospheric plasma motion and changes in the tangent magnetic field.

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S3-13

IMPLICATIONS OF LARGE-SCALE FIELD EVOLUTION

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The solar magnetic field evolves on all temporal and spatial scales. Slowly changing large-scale coronal and photospheric structures originate in active regions and smaller short-lived magnetic bipoles. With models we can connect, with some success, the boundaries of coronal holes to the changing locations of open field regions in the photosphere. The occurrence of coronal mass ejections seems to be related as much to gradual large-scale reorientation of the global structures as to more rapid photospheric events such as flux emergence and solar flares. Other global properties, such as helicity or the location of the heliospheric current sheet, also play an important role in determining the geoeffectiveness of individual CMEs. We compare data from several solar cycles and focus on a few specific events to illustrate these interconnections.

S3-14

A MODERATE SOLAR CYCLE 23?

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Sometime ago a prediction was made that solar cycle 23 will be much more moderate than cycle 22; more like cycle 17 (*Ahluwalia*, 1997, 1998, 1999*a*, *b*, and 2000). This forecast seems to be coming true, as of the end of May 2000. My forecast is in stark contrast to that made by the seasoned solar astronomers who were expecting that cycle 23 may, "potentially be one of the greatest cycles in recent times, if not the greatest." My forecast is based on the recently discovered three cycle quasiperiodicity in the planetary index *Ap* (*Ahluwalia*, 1998). The *Ap* index was designed by Bartels to measure the geo-effectiveness of the solar corpuscular emission from the M regions on Sun. We find that *Ap* is responsive to the time variations observed in the IMF intensity (B) and in the solar polar field. As of now, the solar polar field has reversed and the galactic cosmic ray 11 year modulation recorded by the Climax neutron monitor is very close to the predicted value. We shall review the situation as of the end of August 2000 by updating our analysis. Several important lessons have been learned about the long term behavior of the solar clock. We shall describe them and comment on the physical significance of the inferences that can be drawn.

S3-15

A "CORONAL HOLE-ACTIVE REGION-CURRENT SHEET (CHARCS)" MODEL FOR GEOEFFECTIVE CMEs

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Intense geomagnetic storms around solar maximum are frequently associated with active regions (including flares and/or filaments) occurring close to current sheets and to low-latitude transient coronal holes (CHARCS). For some of the events the temporal and spatial evolution of the transient coronal holes has been studied using YOHKOH X-ray observations. The inter-related CHARCS observations suggest a large-scale reconfiguration of CME associated magnetic fields.

S3-16

PHYSICAL CHARACTERISTICS OF FLUX ROPE CMEs – THEORY AND OBSERVATION

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The dynamics of magnetic flux ropes near the sun are studied by solving model equations [1, 2] which describe a flux-rope-geometry coronal mass ejection (CME). In this model, a CME corresponds to a flux rope with foot points that remain anchored in the photosphere and the eruption is driven by a rapid increase in poloidal flux (flux injection). Model results, computed with a minimum of free parameters, are shown to compare well with LASCO and EIT data for 11 CME events which have flux-rope-like morphological features. We conclude that flux-rope CME's are relatively common events with specific characteristics, many of which are described by the model.
[1] *Krall, J. et al.*, *ApJ*, in press (August, 2000), 2000.
[2] *Chen, J.*, *JGR*, **101**, 27499, 1996.

S3-17

NUMERICAL SIMULATION OF CORONAL MASS EJECTIONS (CMEs) INITIATION AND THEIR ASSOCIATION TO FLARES

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In the seventies it was suggested that CMEs were caused by flare-energy release. This is not supported by the observed time-line that shows the flare generally appears from minutes to an hour after the CME (*Harrison*, 1986; *Hundhausen*, 1999). This temporal ordering of CMEs and flares is also demonstrated by using soft x-ray data from Yohkoh and data from the HAO ground-based coronameter. *Kahler* (1992) concluded that the relationship between flares and CMEs was still unclear, but suggested that flares appear to be a consequence of CMEs. *Low* (1994) suggested the CME-flare relationship can be interpreted as a two-step MHD process. The CME opens up an initially closed coronal magnetic field to eject the mass that was previously trapped in the closed magnetic field. This is followed by reconnection of the open field lines through a dissipative MHD process resulting in a flare. In this paper we used a streamer and flux-rope MHD model (*Wu and Guo*, 1997) to illustrate the two-step MHD process for demonstrating the CME-flare relationship.

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S3-18

THE SUN AS A MAGNETIC VARIABLE STAR GOVERNED BY THE TRIPLE-DIPOLE MODEL

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Observational tendencies reported in the other paper derive the following two laws: (A) The heliomagnetic poles make a heliolatitudinal variation with a 22-year period, and (B) CME tends to occur at the right shoulder and left waist of the one- or two-wave heliomagnetic dip equator. The tendencies imply that the sun is regarded as a magnetic variable star governed by the following triple-dipole model. The poloidal field of the sun is represented by a centered dipole parallel to the rotational axis. While the toroidal field gives rise to magnetic loops extending from active regions to the coronal region. When the loops are high enough to reach the source surface, the fields are conveyed out to the interplanetary space by the solar wind. In this case, the leaked loops are represented by toroidal dipoles located at the active regions. Since the two legs for a sufficiently high loop need large longitudinal span, only a few toroidal dipoles are enough to represent the sun as a magnetic star. In every pre-minimum phase, the large-scale heliomagnetic fields are expressed by only three dipoles: one centered dipole and the two toroidal dipoles. The resultant field from the triple dipoles expresses well the two distinct coronal holes, tilting of the CH axis, recurrent storms, and two stable active regions. Applying the triple-dipole model to other cases in other cycle phases, 22-year changes of various solar phenomena together with the above-stated observational laws of A and B can be synthetically explained.

S3-P01

LONG TERM TEMPORAL VARIATIONS IN THE SOLAR WIND AND THE PLANETARY INDEX *Ap*

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We have studied the data strings for the planetary index Ap, IMF intensity (B), and the solar wind bulk speed (V), for the period 1963 to 1998. The study covers three sunspot number cycles (20, 21, 22). We report the presence of a long term trend in the available B data (1963 – 1998) that corresponds in time with the three cycle quasiperiodicity discovered by us earlier in Ap data (1932 – 1996). A set of regression calculations has been carried out correlating V and B with Ap. Our analysis brings out some of the steady state characteristics of the long term changes in the parameters and their interrelationships. Among other things, our phenomenological study indicates that the solar polar field reversals may be responsible for the existence of the Gnevyshev gap in Ap data. A function proportional to BV^2 describes the time variations of Ap quite well as does the function proportional to the product BV. The latter represents the interplanetary electric field responsible for the magnetosphere - solar wind coupling. We ascribe the Ap time variations to this fluctuating electric field. We conclude that B is a more fudamental parameter and not V.

S3-P02

SOLAR ACTIVITIES ASSOCIATED WITH STRONG SOUTHWARDS IMF NEAR MAXIMUM OF SOLAR CYCLE 23

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Interplanetary events with IMF B_z less than -10 nT with duration longer than three hours tend to lead intense geomagnetic storms according to *Gonzalez and Tsurutani* (1987). Continuous observations of solar wind and solar activities from space enable us to study relation between solar activities and strong southwards IMF. We studied the interplanetary events with strong southwards IMF near maximum of solar cycle 23 using observations from ACE, Yohkoh, and SOHO. Major sources of the strong southwards IMF were interplanetary magnetic flux ropes and intensification of IMFs in sheath region between shocks and plasma ejecta during this period. In some cases southwards IMFs were formed near sector boundaries associated with high-speed streams or shocks.

S3-P03

EVOLUTION OF THE CORONAL MAGNETIC FIELD STRUCTURE BETWEEN TWO ERUPTIVE FLARES

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Two X-class flares were observed with Yohkoh on 18 August 1998. One occurred slightly behind the east limb at about 8:18 UT and the other at longitude E87 about 14 hours later .(22:14 UT). They took place in the same magnetic configuration in the solar corona and showed similar characteristics, *i.e.*, total flux variations in soft and hard X-rays, and soft X-ray flaring loop structure. Surprisingly, a similar eruptive feature was also observed in soft X-rays in these two events. This suggests that the same magnetic configuration was reformed after the first eruption and the energy was stored in it. Then the second energy-release occurred in the same way and almost the same magnitude.

In addition to this, a hard X-ray source was observed above the soft X-ray loop in the highest energy band (53 – 93 keV) of Yohkoh/HXT in the first event. This observational result is an evidence that a primary energy-release, probably magnetic reconnection, took place above the loop. This means that, in only 14 hours, a neutral sheet was formed again and a huge amount of energy was stored. This sequence is the same as a reformation of a coronal streamer after a CME though their time scales are much different. Using this pair of events, we discuss an evolution of the coronal magnetic field structure between two eruptive flares.

S3-P04

FORMATION AND EVOLUTION OF A LARGE SCALE SIGMOIDAL FLUX ROPE

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Recent studies have considered sigmoidal features in the Sun's corona to possess a higher probability of eruption [*Canfield et al.*, 1999, *Hudson et al.*, 1998]. To date, this work has been confined to sigmoidal structures within active regions. Extension *Canfield et. al.*'s study of Yohkoh full disk data has shown that, at this resolution, the soft X-ray 'sigmoid to arcade' scenario alone cannot always be associated with CME onset. In such cases white-light, EUV and Hα data can be used in conjunction with soft X-ray data to confirm the launch of an associated CME [*Glover et al.*, 2000]. This study addresses these issues in considering a large S shaped flux tube observed in Yohkoh/SXT images to form near central meridian on May 7th 2000. This feature did not occur within an active region and during its lifetime, was observed to erupt twice; an associated CME being produced in each case. The first event took place on May 8th when the region was close to central meridian. Rather than being immediately replaced by a loop system seemingly of potential configuration, the region's S-like morphology persisted for a further two days prior to the second eruption on May 10th. At this time a gradual filament lift-off was observed in SoHO/EIT images to take place over a period of several hours. This preceded a CME observed in the South West by SoHO/LASCO. Yohkoh/SXT observations at this time clearly show the characteristic "sigmoid-to-arcade" evolution frequently associated with CME launch from smaller regions having similar morphology. This study traces the evolution of the sigmoidal flux rope from formation to arcade appearance, taking into consideration changes in the underlying photospheric magnetic field and resulting implications for overlying coronal structures. Implications of the observed , large scale "sigmoid-to-arcade" scenario for use as a CME prediction tool will be discussed with a view to quantifying the term 'sigmoid'.

S3-P05

A HALO CME ON MAY 2, 1998

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Using the boundary element method (BEM) for a heliospheric potential field model, the 3-D coronal magnetic structures associated with a flare-CME on May 2, 1998 are obtained by extrapolating from the full-disc magnetogram observed by MDI/SOHO. It shows that a calculated large-scale magnetic arch system connects with the flare-CME source region (AR NOAA 8210), and just covers the dimming region detected by EIT, suggesting that the coronal mass ejection may result from a further destabilization of the large-scale arch system. The magnetic energy for this CME is estimated as the potential field energy contained in the dimming region with a height range of 1.01 – 1.5 solar radius, up to 10^{32} ergs, while the mass is estimated about 1.2 – 3.5 $\times 10^{16}$ g in the same volume. We also analyze magnetic structures and evolution of AR NOAA 8210 using vector magnetograms and the 3-D magnetic configuration based on a force-free field model in order to understand the physical mechanism for this flare-CME.

S3-P06

CME AND ERUPTIVE PROMINENCES OBSERVED IN THE GERMAN-ARGENTINIAN SOLAR OBSERVATORY

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In the recently inaugurated German-Argentinian Solar-Observatory at El Leoncito, San Juan, Argentina, a Hα telescope (HASTA) and a mirror coronograph (MICA) produce daily images of the solar disk and the inner corona.

Since its installation in August 1997 MICA has been imaging the inner corona with high temporal and spatial resolution. Its field-of-view ranges from 1.05 to 2.0 solar radii above the sun center. It can reveal the fast processes that occur in the coronal plasma.

HASTA started operations on May 1998. It has a 110 mm refractor with a focal length of 165 cm and a tunable ($\pm$1 A) Lyot-filter with a bandwith of 0.3 A. In high speed mode full frames can be taken every 2 sec and partial frames every 0.3 sec.

We present recent combined observations as taken by both instruments, mainly those related with eruptive prominences and CME.

S3-P07

ON PATHS OF ERUPTIVE FEATURES VISIBLE IN MICROWAVES

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On the basis of microwave solar images from Nobeyama Radiohelograph (NoRH), we report on statistical features of solar eruptive events. In microwaves (17 GHz), most of eruptive events are originated from polar crown filament or far from active regions, and not associated with flares. This tendency, which is contrary to what seen in soft X-rays with Yohkoh/SXT, probably reflects a temperature dependency in this wavelength. By using 17 GHz synoptic maps from NoRH, we discuss i) where the eruptions visible in microwaves tend to occur and ii) their spatial relation with above magnetic structures (*e.g.*, CMEs and streamers) that can be seen in LASCO coronagraph images.

S3-P08

OBSERVATIONS OF PROMINENCE CAVITY AT LONG-DECIMETER AND METER WAVELENGTHS

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The prominence cavity is an important feature to understand both quiescent filament and CME structure and magnetic field topology. The Nancay Radioheliograph provides images of the Sun at five decimeter and meter wavelengths (frequencies from 450 MHz to 160 MHz). With this instrument, number of cavities above quiescent and active prominences have been detected, for the first time, at long decimeter and meter wavelengths, as brightness temperature depressions. The cavities are observed both on the disk and above the limb. Regarding CMEs, the radio observations of moving cavities on the disk provide the earliest signature of the onset of CMEs.

S3-P09

AN OBSERVATIONAL STUDY OF RELATIONS BETWEEN DBS OF SOLAR FILAMENTS AND CMEs/GEOMAGNETIC STORMS

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CMEs are one of the most responsible phenomena for interplanetary disturbances or geomagnetic storms. And studies of the driving mechanisms for them are one of the hottest topics in both solar physics and space weather.

Sudden filament disappearances on solar surface (DB) or prominence eruptions on solar limb often grow to be CMEs. It is easier to know velocities of eruptive promineces on the limb and relate them to CMEs. But in order to know what is happening in the corona around the filaments and the changes in magnetograms before and during the eruptive phase, it is better to see DBs on solar surface rather than prominence eruptions on the limb.

We have developed a method to know the velocities of filaments from Hα data. With this method we studied the relations between DBs and the corona's responses to them and obtained the following results. (1) Eruptive filaments will cause coronal bright arcade/loop formations. But not-eruptive ones (those go back to or stay on the solar surface) are rerely accompanied by such coronal events. (2) Larger the velocity of an eruptive filament, the more thermal energy will be released in an unit of time and volume in the corona.

In this poster, we will introduce the details of our study as well as the relations between DBs and geomagnetic storms.

S3-P10

OBSERVATIONAL TENDENCIES ON CORONAL HOLES AND CME SOURCES WITH 22-YEAR PERIOD

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One pair of a magnetically positive coronal hole (CH) and a negative antipodal CH tend to move synchronously: The positive CH, for example, moves from the northern heliographic polar cap at the start of an odd solar cycle, via heliographic equator in maximum phase, to the southern polar cap at the end of the cycle. In the even solar cycle, the CH moves from the southern, to the northern polar cap, executing a 22-year variation. The pair CH's are indistinct by a few active region appearing in there in rising and maximum phases, while the CH's become distinct by decreasing active regions near minimum phase. Therefore, the tilting and distinct CH's give rise to clear recurrent geomagnetic storms only just before minimum phase. A pair of antipodal CH's represents a dipolar component having a dipole equator, which is expressed by a one-wave sinusoidal curve on a synoptic chart. When a quadrupole component is involved, the dip equator is expressed by a two-wave curve. CME's tend to occur at the left shoulder and right waist of the one- or two-wave magnetic equator. Sporadic SC storms in and around maximum phase are caused by the CME's when they attach the earth's magnetosphere. When CME's convey out too much coronal field from a limited region, it is replaced by the secondary active region, which becomes a new shoulder or waist. The characteristic observational tendencies on the alternative occurrence and the location changes of CH's and CME's with 22-year period are explained by the theoretical model as reported in the other paper.

S3-P11

SOLAR WIND STRUCTURE WHEN THE POLAR CORONAL HOLE DISAPPEARS

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When the polar coronal hole shrank very small at the solar activity maximum, the coronal polar open fields were encircled by large-scale closed loops and fanned out largely into the interplanetary space. From the interplanetary scintillation (IPS) tomographic analysis during the previous solar maximum, we found the solar wind streams from the small polar open regions were slower ($< 350 - 370$ km/s) than the ambient streams. According to Wang and Sheeley's inverse correlation between solar wind velocity and flux-tube divergence rate, the solar wind coming from the center of the polar coronal hole should be faster than the wind originating from the edge of the hole. However, our result suggests that the low-speed streams emanate not only from the edge but also from the center of the polar open regions. In this study, we confirm the reliability of our result by simulating synthetic IPS observations in hypothetical model polar wind based on Wang and Sheeley's model and discuss what are dominate processes that determine the global structure of the inner heliosphere under conditions of high solar activity.

S3-P12

ORIGIN OF INTERPLANETARY DISTURBANCES DETECTED BY SCINTILLATION MAPPING MEASUREMENTS

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All-sky maps of the scintillation disturbance factor, g value, have been derived from interplanetary scintillation (IPS) measurements at 327 MHz with the four-station system of Solar-Terrestrial Environment Laboratory (STEL). Fifty eight events of interplanetary disturbances (IPD) have been identified from the all-sky g maps taken in 1997 and 1998. In the present paper, we have studied the origin of these IPD events from the comparison with various kinds of the space environment data (in situ solar wind data taken at L1, solar X-ray data, solar energetic proton data, etc). As result, the occurrence of IPD events is found to be closely the associated with appearance of the compression region at the near-Earth solar wind; enhancements of plasma density, wind speed, and interplanetary magnetic field strength at the near-Earth solar wind were observed in more than 80 cases of these IPD events. A close association is also found between the occurrence of IPD events and interplanetary signatures of the magnetic cloud (*i.e.*, low temperature and magnetic field rotation). These facts suggest that the IPD events correspond to the IP shock driven by the coronal mass ejection (CME).

S3-P13

THE BEST USE OF HELIOSPHERIC PHOTOMETRIC IMAGES – TIME-DEPENDENT TOMOGRAPHY OF HELIOSPHERIC FEATURES USING GLOBAL THOMSON-SCATTERING DATA

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Precise photometric images of the heliosphere are expected from the Air Force/NASA Solar Mass Ejection Imager (SMEI) now scheduled for launch in December 2001, and similar images may become available at some future date from all-sky cameras proposed for other NASA missions. To optimize the information available from these instruments, their 2-dimensional sky images need to be interpreted in three dimensions. We will describe the precision required for this, and our current progress in obtaining this precision using images from the SMEI flight optics on the ground.

We have developed a Computer Assisted Tomography (CAT) program that modifies a time-dependent three-dimensional kinematic heliospheric model to fit Thomson scattering observations from the Helios spacecraft photometers. The tomography program iteratively changes these models to least-squares fit observed global brightness data. The short time intervals of the kinematic modeling (< 1 day) force the reconstructions to depend on outward solar wind motion to give perspective views of each point in space accessible to the observations. We plot these models as density Carrington maps and remote observer views for the Helios photometer data sets and compare times of solar minimum and maximum.

S3-P14

NONSTATIONARY SOLAR RADIOEMISSION: RELATION TO CME FORMATION

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Phenomenon preceding the CME formation are studied more effectively using the spectral observations of solar radioemission. The main features of nonstationary radioemission connected to the formation and initial propagation of CME in the lower layers of solar atmosphere have been revealed before by authors [1]. At the same timeone can observe the similar nonstationary events during the time interval without the presence of CMEs. On the basis of the data of radioemission during 1988 (solar patrol observations at *Zimenki* [2]) we investigate the features of nonstationary signatures coincided the "calm" periods of observations. The results of statistic analysis of frequency/time developing of these radio events are presented. The comparison of the revealed features with the same ones connected to the CME formation is carried out. The results are used for a creation of algorithm to forecast the CME onset on the basis of radiodata. This work is supported by Russian Foundation for Fundamental Research (grant No. 00-02-17655) and the Russian Federal Programme "Astronomy".

1. *Durasova M. S., Fridman V. M., Sheiner O. A.* in: *Proc. 9th Europ. Meet. Sol. Phys. "Magnetic Fields and Solar Processes"*, 979, 1999.

2. *Durasova M. S., Fridman V. M.,Podstrigach T. S., Sheiner O. A., Radiophys. Quant. Electron.*, **39**, NN11/12, 1996.

S3-P15

THE BIRTH OF CORONAL HOLES AND CMEs, AND GEOMAGNETIC STORMS

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For the period 1990-1999, we investigated some patterns of the birth of coronal holes (CH), as well as the association of new-born CH with CMEs and geomagnetic storms. CH measurements in the He 10830 A line were used. For 1998 – 1999, the birth of CH was also studied using the SOHO/EIT data. The study revealed some peculiarities in the distribution of the nascent CH across the solar disk depending on the hole's birth place, specifically the appearance of the E-W asymmetry in the locations of the new-born holes relative to the central meridian, and the formation of active longitudes. A separate study was made of the characteristics of CH of two types: short-lived (with lifetimes less than 2 days), and long-lived. It was shown, for example, that at the time of first recording short-lived holes are generally smaller in size when compared with long-lived ones. Such holes are more closely associated with other forms of solar activity, and are characterized by a stronger concentration to zero lines of the large-scale photospheric magnetic field. A comparison was made of two classes of CH: born near or away from active regions. The formation of "open" magnetic field lines in the region of a new-born hole was investigated. It was shown that "open" field lines in the CH region can form within a certain time after the first recording of the hole. Experimental arguments are given in support of the fact that many short-lived CH are produced near coronal mass ejection sites, and are closely linked to CMEs. It was shown that the birth of coronal holes can be accompanied by sudden commencement geomagnetic storms.

S3-P16

PHYSICAL CONDITIONS IN POLAR CORONAL HOLE PLASMAS

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Recent observations of polar coronal hole plasmas are presented. These observations have provided new insight into the physics of polar coronal holes (source region of the high-speed solar wind). In particular, we make use of high-resolution observations made from the SUMER (Solar Ultraviolet Measurements of Emitted Radiation) spectrograph on the spacecraft SOHO (Solar and Heliospheric Observatory) in investigating plasma temperatures, densities, hot ions and abundance anomalies in polar coronal hole plasmas. We also discuss the implications of these findings in addressing the acceleration mechanisms of the high-speed solar wind, one of the outstanding problems in solar physics.

S3-P17

COMPARISION OF 20.02.94 AND 14.04.94 SPE: MULTISATELLITE OBSERVATIONS

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Two SPE 20.02.94 and 14.04.94 were analysed. 20.02.94 SPE was connected with the solar flare. Solar radioemission showed, that the shock wave with velocity $\sim$ 2000 km/s was observed. 14.04.94 SPE was not connected with big phenomenas in Sun. Possibly this SPE connected with CME generated in high solar corona. We analysed these SPE using data of the Geotail, CORONAS-I, GOES, LANL and IMP-8 satellites. We also used geomagnetic data and solar wind data. Geotail, GOES-6 and LANL data permits to separate particles accelerated in outer solar corona by a shock wave for 20 February event. We compare characteristics of shock waves and accelerated particles.

S3-P18

CONTRASTING FEATURES OF SOLAR ELECTROMAGNETIC WAVE AND ENERGETIC CHARGED PARTICLE EMISSIONS

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The sunspots are distributed over the solar surface in a random manner with a dominant distribution near the northern and southern poles. The origin, development and distribution of solar flare producing sites are not yet fully understood. The observed detailed nature of electromagnetic wave emissions and charged particle beam ejections are important sources of revealing details of important solar regions. The solar polar regions are prone to generate coronal holes that are well known source of fast moving solar wind. The incidence of these particle fluxes interact with the earth's magnetospheric plasma and give rise to various observable effects in the dayside and nightside of earth's atmosphere. The solar velocity of charged particles are highly variable; being maximum at the solar poles originating from the opened magnetic field regions. There are other active regions over the solar surface. The sunspots over the entire solar disc depict a quasi periodic variations of 11 year. The earth's atmosphere is known to respond differently and detailed study of atmospheric effects are capable of depicting the variational features of solar electromagnetic wave and charged particle emissions. The computed and observed features of some of these phenomena are discussed especially as a diagnostic tool.

S3-P19

CME AND "BLOB": SIMILARITY AND DIFFERENCE

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Based on analyzing the LASCO/SOHO data we carried out comparative studies of the dynamics of propagation of the CME envelope and a density inhomogeneity ("blob") along a streamer ray. It is shown that the widths of the leading edge of the CME envelope and of the "blob" are nearly identical at $\sim(1.0-1.5)$ R_{Sun}, and remain almost unchanging with the distance from the Sun (at $R = (10-30)$ R_{Sun} for CMEs, and at $R = (3-15)$ R_{Sun} for the "blob"). At the steady state, the "blob" travels as a single whole, changing little its typical size in the direction of motion, unlike the CME which increases its diameter continuously with the distance. However, starting from some critical distance R_* the leading and trailing edges of the "blob" are observed to be decelerated and accelerated, respectively. This is accompanied by a decrease in the "blob's" size in the radial direction and an increase in the density inside it. That is to say, there occurs a collapse of this entity. It appears to be associated with a disturbance of equilibrium between its internal and external pressure. Since the velocity of the "blob" relative to the main solar wind when $R > R_*$ is larger than the local sound velocity, this leads us to suggest that the collapse is elicited by a shock wave produced at its leading edge. The question as to the observation of such a phenomenon for CMEs remains open.

S3-P20

THE FINE RAY STRUCTURE OF THE CORONAL STREAMER BELT FROM LASCO/SOHO DATA

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It is shown that within $R > (3-4)$ R_0 from the solar center the coronal streamer belt consists in a sequence of radial brightness rays. A minimum angular size of the individual ray $\sim 2.0-3.0$ degrees, which is about the same in the directions normal to and along the streamer belt, is independent of the distance from the Sun at $R = (4-6)$ R_{Sun}. The lifetime of the rays can exceed 10 days. From time to time, inhomogeneities of material inside the rays begin to move in the antisunward direction. Plots of increase in their velocity with the distance from the Sun are similar to those obtained in [*Sheeley et al.*, *ApJ*, **485**, 472, 1997] for inhomogeneities that are carried by a quasi-stationary solar wind in streamers. It is concluded that the phenomena discussed in this paper and in [*Sheeley et al.*, 1997] share a common origin. It is suggested that a different origin of solar wind flows in streamers and in coronal holes may be associated with a different character of flows in microtubes of the magnetic field comprising a total solar wind flow. These tubes are observed as brightness rays in streamer belts and plumes in coronal holes.

S3-P21

A NEW METHOD OF ANALYZING THE DATA FROM THE LASCO/SOHO INSTRUMENT

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An outline is given of a new method of analyzing the white-light corona data from the LASCO/SOHO instrument, as well as of some results obtained by this method [*Eselevich, Solar Phys.*, **188**, 299, 1999]. Using uncalibrated white-light corona data from the LASCO C2 and C3 instrument that are available via the Internet, the method makes it possible to determine the following quantitative characteristics of coronal plasma: the angular size of increased-brightness rays of the streamer belt, their lifetimes, and the degree of radiality; to separate a quasi-stationary slow solar wind (SW) from a sporadic one or from nonstationary SW streams flowing within these rays; and to measure the dependence of the velocity on the radius $V(R)$ within distances from 1.3 R_{Sun} to $(20-30)$ R_{Sun} in individual rays both for a quasi-stationary SW and for sporadic SW streams. The method is useful for detecting and investigating the dynamics of formation and motion of "blobs", as well as the collapse phenomenon of "blobs". This technique was used to detect a phenomenon where a selected brightness ray of the streamer belt was occupied by a plasma flow traveling antisunward, *i.e.*, the formation stage of a quasi-stationary SW was observed in the increased-brightness ray. The method can be useful when investigating CMEs, many features of which resembled those of "blobs".

S3-P22

THREE TYPES OF THE PLASMA FLOW IN THE SOLAR WIND STRUCTURE

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The sources of the large-scale stream-structure of the solar wind flow were studied in the areas not connected with the large polar coronal holes using an experimental approach. Radio astronomy data obtained in 1997 – 1998 were compared with SOHO optical observations of the solar corona and magnetic structures derived from the J. Wilcox Observatory data. A correlative relation was obtained between the position of the transonic region of the solar wind and magnetic field strength at the solar corona level. This relation falls into three branches corresponding to three types of the magnetic field structure: an open type with the field lines going in the interplanetary space, closed loop-like type, and intermediate type including both configurations of field lines. The high-speed streams originate above the open configurations, while closed and intermediate configurations produce low-speed solar wind. The evolution of the three-component flow structure was studied at an initial phase of the ascending branch of the cycle.

S3-P23

LONG-PERIOD VARIATIONS OF THE SOLAR WIND STREAM STRUCTURE AT THE SUBSONIC FLOW REGION

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Large-scale stream structure of the solar wind flow near the Sun and its evolution in the course of the 11-year cycle are studied. Basic data were obtained in the radio wave scattering observations using compact natural radio sources at radial distances from the Sun of $R < 14\ R_s$. Regular observations were perfermed on large radio telescopes of the Russian Academy of Sciences at Pushchino, RT-22 at $\lambda = 1.35$ cm and DCR-1000 at $\lambda = 2.7$ m. Radial dependence of scattering, the interplanetary scintillations $m(R)$ and scattering angle $lQ(R)$ were studied in correlation with large-scale magnetic field structures close to the Sun. Existence of quasiperiodic variations of the shape of the radial dependence of scattering was found with a period of about 11 years. These variations arise at high heliolatitudes of about 40 deg $< g <$ 80 deg and are connected with evolution of the large-scale magnetic field structures, with changes in the size of polar coronal holes in the course of the solar 11-year cycle.

S3-P24

CORONAL MASS EJECTIONS AND SPACE WEATHER DISTURBANCES BY THE DATA OF ALMA-ATA HIGH-ALTITUDE NEUTRON MONITOR

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For prediction of space weather it is very important to know the level and variations of galactic cosmic rays (GCR) and possible additional flux of solar cosmic rays observed at the Earth by means of neutron monitors. The Alma-Ata high altitude neutron monitor has a favourable location and very good statistics ($\sim$ 1200 counts per second) to detect different cosmic ray effects conditioned by the space weather. The combination of geomagnetic cutoff rigidity (6.7 GV) and high altitude (3340 m above sea level) makes our station enable to record ground level enhancements (GLE) for the events where maximal rigidity of the protons exceeds 6.7 GV. The analysis of GLE and solar sources of these events connected with coronal mass ejections (CME) are carried out. We have analysed the data of P78-1/SOLWIND, SMM C/P, SOHO-LASCO and some disturbances (GLE and last Forbush decreases) by means of Alma-Ata neutron monitor.

S3-P25

MHD SIMULATION OF ASSOCIATION BEWEEN SOLAR FLARES AND CME

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The possibility of CME and solar flare appearance in the same events is demonstrated in the numerical experiment. A current sheet creation at emergence of a new magnetic flux with field direction opposed to the old magnetic field is demonstrated. The proposed scenario consists in reconnection between the new and old magnetic fluxes. As a result the vertical current sheet is created. Another possibility for current creation consists in slow focusing of phospheric disturbance. It occurs in the vicinity of a neutral line in the active region. At the stage of creation the current sheet is very stable because of plasma flow. During slow evolution the current sheet becomes thinner and thinner. Fast reconnection leads to plasma depletion near the current sheet boundary, and the sheet is transferred into an unstable state. The sheet instability and energy release manifest itself. Plasma acceleration along the sheet due to the electrodynamical force occurs, and strong plasma ejection (CME) from the sheet takes place. This scenario is simulated in the numerical MHD experiments. The PERSVET code is used. The results of MHD simulation confirm numerous observations of solar flare development. Proposed scenario includes the field-aligned currents and fast particles generation, and post flare appearance. The possibility of CME production because of chromospheric evaporation during a solar flare has been also demonstrated.

S3-P26

ESCAPE OF TOROIDAL MAGNETIC BODIES FROM THE SOLAR CORONA AND THEIR PROPAGATION THROUGH INTERPLANETARY SPACE

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It is assumed that the solar atmosphere from its lower levels up to the corona can be treated from the magnetic point of view as medium of coexistence and mutual penetrations of many chanes of toroids. From time to time somewhere in a chain a gap can arise due to unstable processes (reconnection) taking place there. If one or more elements (toroids) are no more firmly connected to the system, even on one side, they begin to accelerate due to action of a diamagnetic force. When a toroid is fully disconnected, it can reach the velocity 1000 km/s or more in the lower corona. After the deceleration by the ambient solar wind and gravity, its velocity may decrease down to 500 km/s near the Earth's orbit. We present a sketch of a possible formation of free toroids and calculations of their speeds in the corona and interplanetary space.

S3-P27

MHD FLOW IN FLARE-LIKE MAGNETIC FIELD

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Based on recent observations of the property and the structure of the solar wind, an analytical theory of magnetohydrodynamics in the flared-like magnetic field is used for discussing the relations among the acceleration of the solar wind in the polar corona with the region and the magnitude of the supplying energy and the opening degree of the magnetic field lines. Main results show that (1) necessary energy source presents a power-exponential function; (2) main region of the supplying energy could be in the region $1-3$ R_S, (solar radius), which is $5-6$ order of magnitude higher than that needed beyond $6-7$ R_S; (3) if the supplying energy region moves from $1-3$ R_S to $6-7R_S$, solar wind speed would continually be enhanced, however the increase of the speed would be slow down beyond $6-7$ R_S and would tends constant, so efficient acceleration region should be in the low corona; (4) needed energy is higher if opening degree of the magnetic field lines is larger. These results may explain new observational factor and could provide an important base for understanding acceleration mechanism of the solar wind.

S3-P28

NUMERICAL SIMULATION OF ASYMMETRIC CORONA WITH MULTI-STREAMER STRUCTURE

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We devise a magnetic multipole fitting-modifying method to numerically study complex asymmetric corona with multi-streamer structures. The method consists of three steps:

Step 1: According to the principle that potential magnetic field can be represented by the sum of dipoles, quadrupoles, etc. We can approximate any potential magnetic field as follows: first place some dipoles, quadrupoles, etc., with appropriate strength in the appropriate position of the computation domain in terms of its observation, then take the sum of these multipoles as the magnetic field.

Step 2: Using Maxwell's equations, make suitable numerical modification on the magnetic field obtained in step 1 in order to get a more reasonable magnetic configuration.

Step 3: Taking the magnetic field obtained in step 2 as initial magnetic field, solve the initial-boundary problem of the time-dependent ideal MHD equations in the region near the corona, and take the asymptotic solution as the steady coronal structure.

The method can also be applied to non-potential initial magnetic field cases, if only we add suitable current distribution in step 1 and 2.

With the help of this method, we reproduce the asymmetric background coronas with multi-streamer structures for the December 23, 1996 CME event and the August 1999 CME event. The test cases show the power of constructing any complicated corona with asymmetric multi-streamer structures. It could make the study of the CME events closer to the space observations, and thus lays a solid foundation for the numerical prediction of space weather.

S3-P29

RELEVANCE OF CMEs TO THE GLOBAL SOLAR MAGNETIC FIELD

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Following the research progress in coronal mass ejections (CMEs), the CMEs have been inferred to be associated with the more severe non-recurrent geomagnetic storms and to drive transient interplanetary shocks accelerating solar energetic particles, this has attracted great attention in solar-terrestrial research. In this paper we used all the ejection events with apparent speed > 470 km/s in the coronal mass ejections observed by SMM coronagraph spacecraft from 1980 to 1989 and investigated the relation between variations of the strength and polarity of the global solar magnetic field (Stanford mean solar magnetic field) and the occurrence rate of CMEs with faster speed (> 470 km/s). The results shown that the 70 per cent of the total numbers of the CMEs with faster speed toward occured the extreme value or the neutral line of the global solar magnetic field.

S3-P30

THE SOLAR ORIGINS OF LARGE GEOMAGNETIC STORMS

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Although it has long been known that large geomagnetic storms ultimately originate from the Sun, the specific solar phenomenon giving rise to such storms is still not fully understood. One consequence is that reliable prediction in advance of the occurrence of large geomagnetic storms has not yet been realized. Suggested causes of large geomagnetic storms have included erupting filaments, eruptive flares, and coronal mass ejections (CMEs). The aim of the work presented in this paper is to explore which types of solar phenomena are the ultimate cause of the largest geomagnetic storms, *i.e.*, which are the most geo-effective. The times of the largest geomagnetic storms are identified using the *Dst* index. Interplanetary data from the ACE and WIND spacecraft are examined near those times to identify the interplanetary features associated with the storms. These features are used to extrapolate back to an inferred start time on the Sun. When possible, comparisons are made with SOHO LASCO data to identify the likely CME which may be the direct cause of the storm. Data from SOHO EIT, Yohkoh SXT, Hα images and radio spectrograms are also used to identify the type of solar event associated with each large storm.

S4-01

PROPERTIES OF INTERPLANETARY MAGNETIC CLOUDS FOR THE ACTIVE VS. QUIET PARTS OF THE SOLAR CYCLE

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We present a review of interplanetary properties of magnetic clouds, whose field structures are usually those of very large magnetic flux ropes (of about 1/4 AU diameter) and which possess intense axial magnetic fields and relatively cool internal proton plasma. The review stresses a comparison of these properties for the quiet vs active parts of the solar cycle and the reasons that magnetic clouds are usually so geoeffective. The study for the quiet interval is based on data from WIND from the the years '95 through '98. That for the active interval is based primarily on data from IMP-8, some earlier IMP's, ISEE 3, and Helios from the years '67 through '82. The clouds are analyzed according to a force free cylindrically symmetric flux rope model, which provides fundamental cloud properties, such as cross-sectional size, axial attitude, axial field intensity, and field handedness, as well as closest approach distance, and a quantitative means of evaluating the "quality" of the model's fit to field data. From a special subset of WIND magnetic clouds, a profile of a generic magnetic cloud in terms of the scalar quantities of field intensity, density, speed, proton thermal speed, and proton plasma β is produced and discussed. A natural by-product of the modeling is the ability to estimate the axial magnetic flux carried by a magnetic cloud. Such an estimate can be compared to an estimate of the solar source flux for a candidate region on the Sun for a (scalar) check of flux consistency and a confirmation of the specific cloud-source relationship. The attitude of the cloud's axis can be compared to the vector properties of the solar source region for further consistency checking.

S4-02

SOLAR WIND EVENTS AND THEIR CORRELATION WITH GEOMAGNETIC ACTIVITY

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I shall discuss solar wind parameters observed from the Wind, Interball-1, IMP-8, and ISEE-3 spacecraft and their relation to geomagnetic activity. I report the recent work of Jurac and Richardson at MIT in which they find a greatly improved correlation between plasma and field structures and geomagnetic activity for large geo-effective events, but they find that they must exclude data from spacecraft for $X_{gse} \leq 40\ R_E$ to get the highest correlations; geomagnetic pulsations and their relation to solar wind pressure pulses when the IMF is northward (work of *Villante et al.* at Universita. *dell'Aquila and Zastenker et al.*, IKI); and special events in the solar wind (such as low flux times and very large changes in dynamic pressure).

S4-03

INTERPLANETARY CAUSES OF VERY INTENSE MAGNETIC STORMS

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The dominant interplanetary phenomena causing intense magnetic storms are the interplanetary manifestations of fast coronal mass ejections (CMEs). Two interplanetary structures are important for the development of such class of storms, involving an intense and long duration B_s component of the IMF: the sheath region behind the forward shock, and the CME ejecta itself. Frequently, these structures lead to the development of very intense storms with two-step growth in their main phases.

These structures also lead sometimes to the development of very intense storms, especially when an additional interplanetary shock is found in the sheath plasma of the primary structure accompanying another stream. The second stream can also compress the primary cloud, intensifying the B_s field and bringing with it an additional B_s structure. Thus, at times very intense storms are associated with three or more B_s structures.

We also discuss evidence that magnetic clouds with very intense core magnetic fields tend to have large velocities, thus implying large amplitude interplanetary electric fields that can drive very intense storms.

S4-04

INTERPLANETARY CAUSES OF MAGNETIC STORMS – A STATISTICAL STUDY

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Magnetic storms are mainly caused by the occurrence of intense southward magnetic fields in the interplanetary medium. These fields can either be formed by ejection of magnetic structures from the Sun, with a substantial out of the ecliptic component, or by stream interaction processes during solar wind propagation. In the present study we examine the occurrence of intense interplanetary fields and magnetic storms during a period of 30 years, with the aim of estimating the relative importance of these two processes. We use the solar wind proton temperature relative to the temperature expected from the empirical relation to the solar wind speed T_p/T_{exp}, together with the speed gradient, and magnetic field signatures to distinguish between the two processes statistically. We find that compression due to stream interaction is at least as important, as the direct effect of ejection of intense fields, and probably more. Only around 25 % of major and large storm-hours are directly associated with a solar wind meeting the criteria $T_p/T_{exp} < 0.5$, a criteria which previously has been found to be a good indicator of ejected material. We examine the magnetic field characteristics of the compressed and the ejected material.

S4-05

INTERPLANETARY MAGNETIC CLOUDS DURING 1997 – 1998 AND THEIR CORRELATION WITH GEOMAGNETIC ACTIVITY

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From data of WIND during 1997 – 1998, we presented 37 candidates of interplanetary magnetic clouds and analyzed changes of the geomagnetic index Dst during these IMC candidates. The result shows the existence of a correlation of the geomagnetic index Dst with southward components of IMF B_z, solar wind velocity V_x, in particular, with the product $B_z \times V_x$. Using linear fitting, the correlation coefficient of Dst and $B_z \times V_x$ is about 0.9. This indicates the geomagnetic activity described by the index Dst during IMCs is determined mainly by the positive induced electric field $E_y = B_z \times V_x$ (*i.e.*, > 0), and can be well predicted by observed values of B_z and V_x of IMCs.

S4-06

RISE TIME OF GEOMAGNETIC SUDDEN COMMENCEMENT

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The geomagnetic sudden commencement (SC) observed in low latitudes (except dayside equator) shows a simple stepwise increase in the H-component. The amplitude reaches the peak value in 3 to 10 min. There is a tendency that a large amplitude SC has short rise time. The time variation rate of the rise shows a clear positive correlation with the amplitude. The followings can be considered as physical quantities which determine the rise time of SC; (1) thickness of the interplanetary shock or discontinuity, (2) time constant of the magnetospheric compression to a sudden increase in solar wind dynamic pressure, (3) difference of magnetospheric propagation time of the compressional wave front from different points of the magnetopause to an observation point on the ground, (4) time for the interplanetary shock or discontinuity to sweep an effective length of the magnetosphere for compression. Here we consider that (4) above is the main cause of the rise time of SC and examine the possibility following procedure below. First we give Alfvén Mach number Ma and a set of solar wind parameters $(\cdot\cdot, Qi, \cdot\cdot)$ in front of the interplanetary shock and calculate dynamic pressure P at both sides of the shock front by using Rankin-Hugoniot relations. Amplitude dH of corresponding SC is obtained from a known experimental relationship between observed dH and a jump of squre root of P across the shock front. Sweeping time T is given by $L/(V + V_s)$ where L, V and V_s are effective length of the magnetosphere for compression and velocity of the solar wind and shock, respectively. The quantities T and dH are calculated for various combination of L, Ma and $(\cdot\cdot, Qi, \cdot\cdot)$ and the resulting relationship between T and dH is compared with observational data. We found that 2×10^5 km is reasonable value for L, effective length for magnetospheric compression by the solar wind shock/discontinuity.

S4-07

NONLINEAR ALFVÉN WAVES AND RELATED VORTEX TUBES IN INTERBALL-1 MEASUREMENTS

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Low frequency wave processes in the dawn low-latitude plasma sheet are studied with INTERBALL-1 satellite. Measurements made in the middle magnetotail are processed. Slow magnetosonic type disturbances are revealed using out-of-phase variations of magnetic field and thermal plasma pressures. Intense Alfvén type waves with disturbances of magnetic field transversely to the local magnetic field line are coupled with these compressional waves. Time-frequency wave spectra, phase and polarization properties are analyzed using complex Wavelet transform. Three-dimensional vortex structures are found to be associated with the waves. Theoretical model of nonlinear vortex tubes is discussed. Energy transport and energetic particle flux modulation are studied. Distinctions between these nonlinear structures and vortices produced by Kelvin-Helmholtz instability in the vicinity of the magnetopause are outlined.

S4-08

COMMENTS ON A STRANGE METAMORPHOSIS BETWEEN SUN AND EARTH; OR: HOW TO TURN A CME INTO A MENACE

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The unique association between fast CMEs observed by coronagraphs close to the sun and interplanetary shocks observed in situ throughout the heliosphere is now well established. However, the details are still far from understood. The often seen 3-part structure of CMEs (bright diffuse outer loop followed by dark void and finally by bright filamentary material) is not discernible in situ. Out there, we usually find a fast forward shock in front of a shell of compressed and heated ambient solar wind plasma, which is well separated from the "driver gas" with its characteritic signatures (magnetic cloud topology, anomalous ion composition, bidirectional electron distributions etc). We have no unique evidence yet, where the shock front would be located with reference to the CME bright loop. Further, the CME void and bright kernel have no unique counterpart in the driver gas, except for the similarity of the magnetic topologies of both the erupted filament and the associated magnetic cloud. These uncertainties are particularly striking since CME observations now reach out to 32 R_s (LASCO on SOHO) which is only 30 R_s away from the closest in-situ observations made by Helios!

S4-09

MAGNETICALLY DOMINATED SOLAR WIND IN THE INNER HELIOSPHERE

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Recent MHD simulations have shown that under well-defined conditions of strong upstream magnetic field planetary bow shocks may exhibit a complex double-front shock topology, with a secondary shock front of intermediate and slow MHD shock type attached to a leading front of intermediate and fast type [*De Sterck and Poedts*, *J. Geophys. Res.*, **104**, 22,401, 1999]. The parameter regime for which this new topology arises has been called the magnetically dominated regime.

We have conducted a statistical survey of such magnetically dominated solar wind conditions in the inner heliosphere using ACE, Wind and Ulysses data. We show the characteristic timescales on which low plasma β and low Mach number conditions occur, that is, periods during which the magnetic pressure dominates the thermal and dynamic pressure. We draw conclusions regarding the possible occurrence of switch-on shocks and the above described complex bow shock topology in front of the terrestrial and jovian magnetospheres.

S4-10

WHAT WE CAN LEARN ABOUT INTERPLANETARY MAGNETIC FLUX ROPES FROM A TORUS-SHAPED MODEL

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A loop-shaped structure with both ends rooted on the sun is widely accepted as a global confifuration of the interplanetary magnetic flux rope. This geometry must be taken into consideration in interpreting magnetic field variatiations observed when the spacecraft traversed curved portions of such structures. This paper presents the results of a search for interplanetary magnetic flux ropes that can be interpreted by a torus-shaped model but not by a simple cylinder model. We have found three types of events: (1) casses in which the directions of magnetic field vectors are maintained rather unchanged, (2) cases in which the magnetic filed rotation changes from clockwise to anti-clockwise, or vice versa, and (3) cases in which magnetic field vectors rotate by about 360 degrees. This finding implies that the occurrence frequency of the interplanetary flux ropes are much higer than that expected hitherto. Another important finding is that the folding of the loop strucure is not very strong. The major radii are generally in the range of $0.3 - 0.7$ AU. This feature is consistent with a recent finding about the magnetic polarity and chirality of interplanetary magnetic flux ropes by *Kahler et al.* (*JGR*, 1999).

S4-11

PITCH ANGLE DIFFUSION OF CHARGED PARTICLES BY FINITE AMPLITUDE MHD WAVES

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We discuss some fundamental properties of pitch angle diffusion of charged particles by MHD waves by performing test particle simulations. We integrate in time ion trajectories under influence of static magnetic field turbulence, which is given as superposition of parallel Alfvén waves with equal propagation speeds (slab model). Although each wave mode is non-compressional, superposition of the waves yields ponderomotive compressional fields, which may mirror-reflect the ions. The wave phases are assumed to be random. When the turbulence energy is small, the particles stay within the hemisphere they belonged to initially. However, as the turbulence energy level is increased, substantial portion of particles start to traverse 90 degrees pitch angle. We propose a model to describe the pitch angle diffusion in a presence of finite amplitude MHD waves, which incorporates both mirror reflection and anomalous diffusion at 90 degrees pitch angle.

S4-12

STREAMING LIMITS, SPECTRAL KNEES, AND THE HAZARD OF SPES IN SPACE

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In the largest and most hazardous solar energetic particle (SEP) events, acceleration takes place at shock waves driven out from the Sun by fast coronal mass ejections CMEs. Multi-spacecraft studies show that particles from the largest events span more than 180 degrees in solar longitude, like the shocks they come from. Protons streaming away from shocks generate waves that trap particles in the acceleration region, limiting the outflowing particle intensities but increasing the efficiency of acceleration to higher energies. Thus, early intensities are bounded, but at the time of shock passage, they can suddenly rise to a peak. These shock peaks extend to >500 MeV, even at 1 AU in the largest events, creating a serious "delayed" radiation hazard. At high energies, the spectrum steepens to form a "knee." The energy of this spectral knee can vary from ~10 MeV to ~1 GeV depending on shock conditions, greatly affecting the radiation hazard.

S4-13

ROGUE EVENTS: OBSERVATIONS, MODELING, AND CONSEQUENCES FOR SHOCK ACCELERATION

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About once during a solar cycle, in some tens of MeV extremely large energetic particle events can be observed – with intensities often exceeding the counting capabilities of instruments. These events are related to converging shocks. On the other hand, there are many pairs of converging shocks that do not produce significant particle enhancements. From the observations and numerical modeling we will identify conditions under which these rogue events can form. Part of the results also can be applied to the acceleration of tens of MeV particles at single shocks. In addition, since they are high fluence events, rogue events play an important role in space weather.

S4-P01

DYNAMICAL EVOLUTION OF CMEs IN INTERPLANETARY SPACE

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Directional distributions of outward speeds of white-light CMEs, which were observed by LASCO coronagraphs of SOHO, are compared with those of related interplanetary disturbances. The principal data source of the solar wind near the sun is IPS observations. For a high-speed (> 1000 km/sec) white-light CME of 6 November 1997, which appeared above the western solar limb, observed solar wind speeds in the region apart from the heliospheric current sheet were similar to those of the relevant CME, although considerable deceleration was seen in the region along the current sheet. For a very complicated halo CME on 2 May 1998, the apparent speed of the CME along the heliospheric current sheet was low (200 km/sec), but an interplanetary disturbance with the speed of 500 km/sec was observed in the same radial directions. These examples suggest that the heliospheric current sheet decelerate an "initially" high-speed CME and that an initially low speed CME can be continuously accelerated within the sheet.

S4-P02

QUASI-STATIONARY SOLAR WIND IN RAY STRUCTURES OF THE STREAMER BELT

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On the basis of analyzing the LASCO/SOHO data using the method presented in [*Eselevich, Solar Phys.*, **188**, 299, 1999], it is shown that the main quasi-stationary solar wind (SW) with a typical lifetime of up to 10 days or longer flows within the rays of the streamer belt. Its velocity was measured as a function of R; it increases gradually from $V \sim 3$km/s at $R \sim 1.3R_{Sun}$ to $V \sim 170$ km/s at $R \sim 15R_{Sun}$. We detected and investigated the movement of the leading edge of the main solar wind at the stage when it occupied an individual isolated ray, *i.e.* at the formative stage of a quasi-stationary plasma flow with the largest SW plasma density. This process, when observed in the white light, looks like a relatively rapid (within $\sim$ 24 hours) enhancement of the ray brightness. It is pointed out that it is such portions of the streamer belt containing SW streams with maximum density and intersecting the ecliptic plane that are the most geoeffective when colliding with the Earth's magnetosphere even in the absence of sporadic SW streams.

S4-P03

EVOLUTION AND PROPAGATION OF A TOROIDAL MAGNETIC CLOUD IN THE SOLAR WIND: MHD SIMULATIONS

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Evolution and propagation of a toroidal magnetic cloud through interplanetary space is investigated using three dimensional magnetohydrodynamic self-consistent numerical simulations. Our interest is concentrated namely to study how interactions of the magnetic cloud with ambient medium change its initial shape and how this deformation depends on the initial orientation of the cloud near the Sun. It may help to clarify how starting conditions have influence on the cloud geoeffectiveness.

S4-P04

DRAPERY OF IMF AROUND MAGNETIC CLOUDS OF DIFFERENT GEOMETRIES

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It is known from observations that the maximum strength of the magnetic field draping around a magnetic cloud is of the order of the field inside the cloud. We investigate theoretically how this strength depends on geometrical parameters of magnetically closed bodies like cylinders, spheroids, and toroids. These bodies are inserted into an initially homogeneous ambient magnetic field and then a distortion of the external field is calculated under the assumption that the field remains potential. In our modeling no shock formation is present, *i.e.*, our results are applicable only for magnetic clouds slowly moving with respect to the solar wind. Preliminary calculations indicate that a toroidal body yields the maximum increase in the magnetic field magnitude, which is around $4-5$ times (in contrast to cylindrical and spheroidal bodies with the maximum increase about 2 times). Such a large increase may explain a trigger of a strong geomagnetic storm only by the B_z component of the draped field, even if there is no strong B_z component in the cloud proper.

S4-P05

NUMERICAL STUDY FOR TEMPORAL BEHAVIOR OF COMPONENT B_Z OF IMF DURING JANUARY 10 – 11, 1997 EVENT

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Magnetic storm is one of the most important topics in space weather and attracts lots of attentions of scientists worldwide. In the study for the relations among the solar wind, interplanetary variables and magnetic storm, it has been believed that the temporal behavior of component B_z of IMF play a crucial role in forecasting magnetic storm. Generally, it is an important and clear signal for predication of the geomagnetic storm when B_z suddenly turns southwards and then northwards. In the duration of Jan. $10-11$, 1997 storm, WIND has observed southward process of B_z. This event is thought to be the cause of the malfunction of an American satellite. In this paper, we attempt to simulate the behavior of B_z at 1 AU during Jan. 1997 event and provide a quantitative comparison between the numerical result and the observations of WIND. Based on the observations of the solar source surface magnetic field of Jan. 1997 event, the initial and boundary conditions are composed and the relatively realistic solar wind background is obtained by using a three-dimensional MHD model. Furthermore, by using a time-transient MHD model, the temporal behavior of B_z is given numerically and a satisfactory comparison with the observations of WIND is also offered. Our results show that the simulated and observed behaviors of B_z are basically consistent.

S4-P06

THE SIMULATION OF CORONAL MASS EJECTION-SHOCK SYSTEM IN THE INNER CORONA

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In the concept that coronal mass ejections (CMEs) are usually originated in large closed magnetic field regions which are found in the coronal streamer belt near the solar surface, we have used a thermal driving force so strong that portions of the closed magnetic fields were carried away by the strong disturbance. A CME-shock system is obtained in the inner corona. The "legs" of loop-like CMEs are again obtained at the interface between the coronal open and closed magnetic fields. However, there is no counterpart in outer space. The shock is a combined one with an intermediate shock near the equator at its early stage. Ultimately, it becomes a pure fast shock. A plasmoid with higher density and bubble-like magnetic fields is formed behind the MHD shock wave. It propagates at high speed. The results show that the high-speed plasmoid does not propel the MHD shock in front of it; rather, the plasmoid forms behind the MHD shock.

S4-P07

REAL-TIME HELIOSPHERIC FORECASTING – THREE-DIMENSIONAL RECONSTRUCTION OF HELIOSPHERIC FEATURES USING REMOTE-SENSING Data

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We have developed a Computer Assisted Tomography (CAT) program that modifies a time-dependent three-dimensional kinematic heliospheric model to fit interplanetary scintillation and/or Thomson scattering observations. The tomography program iteratively changes these models to least-squares fit observed global data. The short time intervals of the kinematic modeling ($<$ 1 day) force the heliospheric reconstructions to depend on outward solar wind motion to give perspective views of each point in space accessible to the observations, and can reconstruct interplanetary CMEs as well as corotating structures. We plot these models as velocity or density Carrington maps and remote observer views for the data sets in real time in order to depict heliospheric structures prior to their arrival at Earth.

S4-P08

DISTURBANCE OF A SECTOR BOUNDARY BY A CORONAL MASS EJECTION LEADING TO FORMATION OF STRONG CURRENT DENSITIES

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Usually currents on the HCS are not very strong and only compensate the magnetic field jump of up to $5 - 7$ nT on the sector boundary near 1 AU, and therefore cannot be considered as a possible source of strong magnetic disturbances. But if a part of the curved HCS is pushed instantly by a CME from its normal position into area where B was around 10 nT and the plasma density increased by the material from the CME, then this situation can yield strong current layers producing rotation of B_z from -20 nT to 20 nT similarly what is observed inside magnetic clouds. We apply this approach to explain the strong geomagnetic activity on April 7, 2000.

S4-P09

THREE-DIMENSIONAL MHD CODE WITH ADAPTIVE MESH REFINEMENT FOR MODELING SOLAR WIND FLOWS AND INTERPLANETARY DISTURBANCES

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A three-dimensional (3D) magneto-hydrodynamical (MHD) simulation code with an adaptive mesh refinement (AMR) scheme is developed in order to model propagation of disturbances in an interplanetary space. This method places fine grids over areas of interest such as shock waves in order to obtain high resolution and places uniform grids with lower resolution in the other area; this procedure is performed at every time step. Thus the AMR scheme can provide a combination of high accuracy and computational robustness. We show results for a simplified model of a shock propagation, which strongly indicates that the AMR technique has the ability to resolve disturbances in an interplanetary space.

S4-P10

SOLAR ACTIVITY LARGE-SCALE DISTURBANCES EVOLUTION CAUSED BY THEIR TRANSPORT FROM THE SUN TO THE EARTH

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The reverse task for the definition of large-scale disturbance origin, caused by solar activity on the basis of observation data of these modified isolated disturbances in the Earth vicinity was raised. For this purpose, first, the possible sources of isolated large-scale disturbances, registered by Satellite system OMNI at the Earth vicinity were identified. Further, the evolution of the most widespread large-scale disturbances during their carry from the Sun to the Earth was investigated by the method of two dimention MHD computer modeling. As the input conditions for initial disturbances, characteristic parameters, adequate to heliospheric streamer, jet layers, fibres, fast magnetic clouds and shock waves were chosen. It was taken into account, that considered disturbance can be also presented as a combination of different sources. The influence of velocity and temperature values of background solar wind on the process of evolution of given MHD disturbances and amplitudes of arising secondary disturbances is considered. As a result of the carried out modeling, the conclusion about the most probable reasons of two tens large-scale isolated disturbances, registered on the Earth's orbit, attacking the Earth magnetosphere in 1979 is made.

The work was supported by RFBR (grants NN 00-05-64689), by scientific program "University of Russia, 2000" and by INTAS-CNES (grant N 97-1450).

S4-P11

GEOEFFICIENCY OF THE FLARE STREAMS IN DEPENDENCE ON THE CONFIGURATION OF THE MAGNETIC FIELDS ON THE SUN AND IN THE SOLAR WIND

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Intensity of geomagnetic disturbances associated with the flare streams in the solar wind is investigated.

It is shown that the intensity of geomagnetic disturbances increases with the increase of a angle $|\Delta\Theta|$ between the magnetic fields within the compressed solar wind region and the stream body, or, which in important for the prediction of the stream geoefficiency, with the increase of the angle $|\Delta\Theta_s|$ between the magnetic fields within the flare region and in the region westwards of the latter.

The maximum level of the geomagnetic activity is reached in the case of a relatively big angle $|\Delta\Theta_s|$ with the magnetic field in the active region of the Sun pointed southwards.

S4-P12

NONSTATIONARY PERIODOCITIES DETECTED IN SOLAR WIND DURING SPACE ERA

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A spectrum of values of interplanetary magnetic field module, velocity V prepared on a basis of measurements in space during 1964 – 1997 near 1 AU, has been calculated by MGM method. MGM is capable of making a self-consistent selection of trends from a data set and singling out harmonics with varying phase and amplitude, so that one can detect a development of nonlinear processes in data. According to power decrease the spectrum has the following periods (confidence level > 99.8): $T = (10.8 \pm 0.2)$ years, $T = (8.8 \pm 0.1)$ years, $T = (3.73 \pm 0.03)$ years, $T = (1.322 \pm 0.005)$ years and the others. The non-stationary periodicities, extracted for the first time, at $T = 1.32$ years and $T = 141.6$ days testify to the non-linear mechanism of their generation. Our study shows that behaviour of non-stationary cycle at $T = 1.32$ years: phase shifts (crashes), oscillation regime (damping or building up) does not depend from solar cycle. That points to the fact that the source of these oscillations lies lower of the solar convection zone. Characteristics of the cycle have a connection with the solar radius changes and rotation velocity near the base of convection zone. Spectrum V has more nonstationary periodicities in spectrum and the other relations between spectral amplitudes. Characteristics of these nonstationary cycles in V are derived and discussed. Our study shows that the derived non-stationary cycles are extremely repeatable mechanism that determine interplanetary disturbances at the Earth's orbit. Physical mechanism for explanation of the non-stationary cycles is suggested and discussed.

S4-P13

SMALL-SCALE PLASMA HOLE IN THE SOLAR WIND

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A sudden drop in the solar wind dynamic pressure was observed by the ACE spacecraft (X:243, Y:9 R_E) at 18:54 UT on Feb. 11, 1999. The proton density decreased from 42/cc to 6/cc in concurrence with an increase in the magnetic field strength and decreases in the proton velocity and temperature. About 100 minutes later, the density increased to 30/cc accompanied by a decrease in the field strength and an increase in the proton temperature. The structure was also measured by IMP 8 (X:16, Y:28 R_E) and WIND (X:−30, Y:−72 R_E). The structure looked like a "plasma hole" in the solar wind, which was in the front of a high-low speed stream interface and was embedded in the corotating interaction region (CIR). In response to the plasma hole, a geomagnetic negative-positive sudden impulse (SI−/SI+) pair was observed at the low-latitude. By examining the time-lag of the convection from ACE to IMP 8, the Earth, and WIND, we found the plasma hole aligned with the CIR. It might relate to the heliospheric plasma sheet (HPS) which is identified by density enhancement and diminished magnetic field strength and proton temperature. The temporal going out of HPS can explain the variation of the proton density and field strength, but can not that of temperature mentioned above. The structure seemed to have similarities with magnetic clouds. However the duration was too short and no field rotation were found in it. In the paper, we show the characteristics of the plasma hole and discuss it's relationships with CIR, HPS, and magnetic clouds. We make use of the geomagnetic field data to estimate the spatial scale of the structure.

S4-P14

THE GEOEFFECTIVENESS OF SOLAR WIND ALFVÉN WAVES

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Solar wind Alfvén waves interact with the bow shock and generate fast, intermediate (Alfvén) and slow modes in the magnetosheath. Some of the wave energy is transferred from the solar wind into the Earth's magnetosphere and dissipated in the ionosphere. Multi-point measurements of solar wind Alfvén waves by ISTP satellites are presented. Geoeffectiveness of these interplanetary disturbances has been examined using data from ground-based radars, ionosondes, magnetometers and optical instruments. Case studies are presented that show a variety of magnetospheric/ionospheric phenomena including pulsed ionospheric flows, polar patches, gravity waves, global convection re-configuration and substorm intensifications. These are discussed as responses to solar wind Alfvén wave coupling to the magnetosphere/ionosphere system.

S4-P15

THE GLOBAL CONFIGURATION OF MAGNETIC FIELD LINES WITH SUNWARD-PROPAGATING ALFVÉN WAVES

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Alfvén waves which propagate toward the sun in interplanetary space have been searched in the magnetic field and the low energy particle data obtained by GEOTAIL in the solar wind during the period from February 2, 1995 to November 30, 1995, in order to find magnetic loops which have both ends on the sun. The Alfvén waves on such field lines will propagate toward the sun in interplanetary space. The data were divided into 30-minute bins. Alfvénic periods were selected by using Walen relationship. Sunward-propagating Alfvén waves were found in 30 events out of 564 Alfvénic periods detected. These events were compared with bidirectional electron events (> 76 eV) to distinguish whether the waves were propagating along an open kinked line, or propagating on a closed loop. Generally, a bidirectional electron event is used as an indicator of closed loops of magnetic field lines. Among the 30 events, simultaneous observation of LEP was available on 17 events. Only one event of them coincided with intermittent bidirectional electrons, suggesting that the magnetic field line was a closed loop. The period of observation of the sunward-propagating Alfvén waves were longer than that of the bidirectional events. It may be due to lack of bidirectional electrons on closed field lines, or, it is likely that the waves were propagating along open field lines draping about closed loops with bidirectional electrons. About 50 % of the sunward-propagating Alfvénic waves were observed within 20 hours before or after bidirectional electron events.

S4-P16

INTERPLANETARY MAGNETIC STRUCTURES - WHAT CAN BE INFERRED FROM GEOMAGNETIC PROXIES?

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New geomagnetic proxies for the interplanetary magnetic field B_y- and B_z-components have been developed. The proxies are derived at an hourly time-scale and may therefore be used to monitor structures, which passes the Earth on time-scales of the order of 1 day, such as interplanetary flux-ropes associated with CMEs.

The new proxies are based on data from high-latitude magnetic stations and derived from a simple linear multi-regression between satellite measurements of B_y and B_z and the magnetic perturbation at ground. The advantage of the proxies compared to direct measurements is that the groundbased observations are almost without data gaps, and that they have been running much longer than satellite data are available. We explore the possibility to use the proxies to monitor interplanetary magnetic structures, and present the first statistical results.

S4-P17

CLUSTER ANALYSIS IN INVESTIGATION OF INTERCONNECTION OF PHYSICAL PROCESSES DURING MAIN PHASE OF VERY INTENSE ($Dst < 200$ nT) GEOMAGNETOSPHERIC STORMS

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Main phases (MPs) of very intense geomagnetospheric storms (GMSs) can be thought of as complex system physical phenomena. State of geomagnetosphere-ionosphere system is described by Dst-index, ring-current DR field, $F = dDR/dt + DR/\tau$, total magnetosphere energy dissipation, AE- and AL-indices. Interplanetary medium is described by measuring solar wind (SW) and interplanetary magnetic field (IMF) parameters and also by "derivative" parameters, say, E_y, Akasofu (FA) and Murayama (FM) parameters, dynamic pressure (P_sw) and so on. The hourly-averaged data are used. Effectiveness of cluster analysis (realized in form of "nearest neighbour" method) of empirical and theoretical data is demonstrated on example of three MPs with $10 - 13$ hours duration. Analysis of obtained dendrites of processes correlativity for MPs taking into account that only nearest neighbours have a claim on role of geoeffective parameters is done. The following Pearson's coefficient of correlation r for tight couplings are obtained: 1. 2 April 1974 MP ($Dst = -211$ nT, $dDst/dt = -19$ nT/hour, $AE = 960$ nT, $r(Dst, DR) = 1$, $r(AE, AL) = -0.99$): $r(Dst, FM) = 0.9$, $r(Dst, FM) = 0.85$, $r(DR, B_y) = -0.98 = r(F, B_y)$, $r(F, n) = 0.97$, $r(F, T) = 0.76$, $r(AL, V) = 0.93$; the $Dst - AE$ couplings is weak. 2. 3 April 1979 MP ($Dst = -202$ nT, $dDst/dt = -16$ nT/hour, $AE = 1160$ nT, $r(Dst, DR) = 0.98$, $r(AE, AL) = -0.87$): $r(Dst, B) = 0.94$ (the transversal component of B play important pole in this coupling), $r(DR, T) = 0.92$, $r(AL, B_x) = 0.6$; the Dst-AE coupling is weak. 3. 28 August 1978 MP ($Dst = -226$ nT, $dDst/dt = -22$ nT/hour, $AE = 150$ nT, $r(Dst, DR) = 0.99$, $r(AE, AL) = 0.84$, $r(Dst, AE) = -0.1$): $r(Dst, B_x) = 0.88$, $r(Dst, B_y) = -0.88$, $r(DR, B_x) = 0.93$, $r(DR, B_y) = -0.89$, $r(F, n) = -0.97 = r(F, P_{sw})$, $r(F, FM) = 0.92$, $r(AE, di) = 0.6$, $r(AL, V(di - B_z)) = -0.7$; from such tested parameters as B_sV, FM and FA the most geoeffective for Dst, DR and F is FM. Obtained results support an

idea about multicausality and multivariance of geomagnetospheric processes during MPs of very intense GMS. It has been revealed essential role of IMF B, B_{x-} and B_{y-} component, n, P_{sw}, FM, and protone temperature T in development of studied MPs. There is decoupling between geomagnetospheric and auroral processes during such events and some weakening of auroral electrojet dependency on interplanetary parameters.

S4-P18

CLUSTER SCALE Dst–AE– B_Z CLASSIFICATION OF GEOMAGNETOSPHERIC STORMS (GMSs) MAIN PHASES (MPs)

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A system representation of GMSs MPs as totality interconnected physical processes (IPPs) suggests an integrity of their external manifestations. This offers possibility for MPs classification according to some basic process or sets of such processes. External cluster scale classification of 31 events is realized according to Dst and AE indices and IMF B_z component with the aim of separation of MPs clusters with rather uniform in scale and in form and with alike in IPPs structures. Two MPs clusters types (C1, C2) and five MPs isolators (I) are separated. They are characterized by the following averaged basic processes peak values: C1: $Dst = -51$ nT, $AE = 832$ nT, $B_z = -8$ nT; C2: $Dst = -130$ nT, $AE = 1025$ nT, $B_z = -13$ nT; I: $Dst = -174$ nT, $AE = 1238$ nT, $B_z = -20$ nT. The content physical analysis of the MPs for C1 and C2 and for three I (I3: with $Dst < -200$ nT) is carried out on the base of correlativity clustering of 32 processes. The MP of every cluster and of I3 have common tightly IPPs structures: C1: Dst, B, B_t, B_y, V, n, P_{sw}; C2: Dst, B, B_t, B_y, B_z, E_y, V, T; I3: Dst, AE, B, B_t, B_x, B_y, B_z, V, n, P_{sw}, T. Despite the fact that the C1, C2, I3 have common basic tight IPP structure nevertheless their full IPPs structures are differ from one another. Hence theirs MPs are characterized by different physical development of which it is impossible to interpret by single known coupling function (say, B_z, E_y and so on). It is worth noting, the role of the well-known epsilon-function in such MPs development is not so significant as one might expect (except some storms). The IMF By component is of considerable importance. The Dst and AE of the MPs have different coupling functions, as a rule, and that AE-Dst relationships are varied over wide limits. The obtained results support idea about multicausality of the MPs (B_t-IMF transversal component).

S4-P19

THREE-DIMENSIONAL MHD SIMULATION OF THE SOLAR WIND STRUCTURE OBSERVED BY ULYSSES

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Ulysses is till now the first spacecraft to explore the high latitude regions of the heliosphere. During its first rapid pole-to-pole transit from September 1994 to June 1995, Ulysses observed the lasting fast speed flow with magnitude reaching $700-800$ km/s at high latitudinal region except the $\leq 20°$ area near the ecliptic plane where the speed is only 400 km/s or so. The observations also showed a sudden jump of the velocity across the two regions. Ulysses's observations are totally different with the previous hypothesis of latitudinal structure of solar wind. In this paper, based on the characteristic and representative observed materials of source surface magnetic field of the sun and K-coronal polar brightness, the nearly real solar wind background field is obtained and then the large-scale solar wind structure mentioned above is reproduced by using a three-dimensional MHD model. The numerical results are basically consistent with the Ulysses observations. Our results show that the distributions of magnetic field and plasma density on the solar source surface play a crucial role in controlling this structure, especially the profile of the current sheet. Furthermore, the numerical model used here has a robust ability to simulate this kind of large-scale solar wind structure.

S4-P20

MAGNETOSHEATH ELECTRONS IN ANOMALOUSLY LOW DENSITY SOLAR WIND OBSERVED BY GEOTAIL

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We present an overview of the magnetosheath electron observations in the anomalously low density solar wind on 11 May 1999 observed by the Geotail spacecraft. We observed anisotropic 'strahl' component not only in the solar wind but also in the magnetosheath. Strahl is observed during the interval of $6-21$ h UT and most enhanced in the interval surrounding the solar wind density minimum in $\sim 18-19$ h UT. Its temperature seems positively correlated to its flux. We also evaluate the density and temperature of 'core' component below 100 eV. The variation of core density is associated with that of proton density. Its temperature is continuous, and suddenly decreased after the density minimum in $\sim 18-19$ h UT. We also compared our downstream data with upstream one observed by the ACE spacecraft. We conclude that the electron acceleration and heating at the bow shock is executed in the usual mechanisms even in the low density solar wind.

S4-P21

LOW-FREQUENCY MHD WAVES ASSOCIATED WITH PLASMA TEMPERATURE ANISOTROPY IN THE MAGNETOSHEATH OBSERVED BY GEOTAIL

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We have investigated transverse fluctuations in the magnetic field and in the plasma velocity in the magnetosheath using Geotail data. In the frequency range below about 0.01 Hz, a change in the magnetic field (dB) is often linearly correlated with a change in plasma velocity (dV), satisfying the Walen relation expected from the theory of MHD wave propagation.

We investigated the correlation between dB and $(\mu\rho)^{0.5}dV$, and found well-correlated events in a wide range of radial distances of the magnetosheath, $-42\ R_E < GSM - X < 6\ R_E$, where R_E is the radius of the Earth. In the well-correlated events the ratio between the two values is nearly equal to the unit but $(\mu\rho)^{0.5}dV$ is sometimes less than dB. Further analyses suggest that an anisotropy of the plasma temperature possibly modify the ratio between dB and $(\mu\rho)^{0.5}dV$.

The correlation is sometimes positive and sometimes negative, depending upon the angle between the magnetic field and the plasma flow direction. The results indicate that, in a frame moving with the plasma, the waves propagate uni-directionally in the same direction as the plasma flow in a draping field. In other words, the wave energy is always propagating simultaneously antisunward and outward. Our results strongly suggest the possibility that the signals in the magnetosheath originate from the magnetopause.

S4-P22

IMPLICATION OF BEHAVIOUR OF ENERGETIC PARTICLES ASSOCIATED WITH INTERPLANETARY SHOCKS FOR SPACE WEATHER

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We report the phenomena of enhancement of energetic particles flux (47- to 1910-keV) as a precursor of an approaching interplanetary shock wave, using data observed by EPAM (Electron, Proton, and Alpha Monitor) and SWEPAM (Solar Wind Electron, Proton and Alpha Monitor) onboard the ACE satellite. The proton flux begins to enhance in advance of the arrival of an interplanetary shock at the L1 point and the time for the peak of thosed flux almost coincidences with the time for the shock passage. This behavior is consistent with the standard Fermi shock acceleration theory. We seek characteristic time constant during enhancement of a proton flux before a shock passage through statistical study and investigate possibility of prediction of an approaching interplanetary shock for space weather. Acceleration mechanism of energetic protons are also discussed using numerical simulations.

S4-P23

PRECURSORS OF GEOMAGNETIC STORMS OBSERVED BY MUON DETECTORS

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We report the first systematic survey of cosmic ray precursors of geomagnetic storms. Our dataset comprises the 14 "major" geomagnetic storms (peak $Kp > 8-$) identified by *Gosling et al.* (1990) together with 25 large storms (peak $Kp > 7-$) observed from 1992 through 1998. After eliminating events for which the muon detector network had poor coverage of the sunward IMF direction, we determined that 15 of the remaining 22 events (68) had identifiable cosmic ray precursors with typical lead times ranging from 5 to 10 hours prior to the Storm Sudden Commencement (SSC). Of the 15 precursors, 10 were of the "loss cone" (LC) type which is characterized by an intensity deficit confined to a narrow pitch angle region around the sunward IMF direction. Cosmic rays in the loss cone presumably originate in the cosmic ray depleted region downstream of the approaching shock. The remaining 5 precursors were of the "enhanced variance" (EV) type which is characterized by intensity increases or decreases that do not systematically align with the IMF direction. The incidence of precursors increases with storm size; for instance 89 % of storms with peak Kp greater than or equal to 8.0 had precursors. Our results show that muon detector networks can be a useful tool in space weather forecasting. However, new detector (s) installed to fill major gaps in the present network are urgently required for better understanding the nature of precursors and for reliable space weather forecasting.

S4-P24

APPLICATION OF COSMIC RAY FORBUSH-EFFECTS RESEARCH IN INVESTIGATIONS OF INTERPLANETARY MOVING DISTURBANCES AND IN FORECASTING OF SPACE DANGEROUS PHENOMENA

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We show that investigations of cosmic ray Forbush-decreases and precursory effects before the start of great geomagnetic storms give important information on the dynamics of the moving from the Sun disturbances and their magnetic structure. These disturbances are connected with great solar flares, with strong interplanetary shock waves and coronal mass ejections. Especially important information is obtained from data corresponding to different neutron multiplicities (for determining of energy spectrum of primary variations) and from cosmic ray anisotropy for each hour (obtained by the method of global survey on the basis of one-hour data of many neutron monitors from the world-wide network). We analyzed many Forbush-decreases and related precursory effects and came to conclusion that this type of research can be made in the future mainly automatically with on-line data in the framework of the Project of International Cosmic Ray Service. We show that in near future will be possible to obtain important information on the dynamics of interplanetary disturbances in real time scale from on-line hourly cosmic ray data. This information may be used for forecasting of the development of dangerous situations in space by using on-line information on the precursory effects caused by the interaction of high energy particles with interplanetary shock waves and on the motion of the Sun's magnetic clouds.

S4-P25

GEOPHYSICAL MANIFESTATIONS OF LARGE-SCALE SOLAR WIND DISTURBANCESAT INTERSECTION OF THEIR FLANKS BY THE EARTH

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The events of Forbush effects and geomagnetic storms when the Earth intersects the flanks of large-scale solar wind disturbances are considered. The criterion of intersection of flanks of solar wind structures registered in-situ by multipoint measurements aboard the different spacecrafts is the condition that one of them has not registered a disturbance. By other spacecrafts the orientation of solar wind disturbance forward front boundaries has been determined. The comparison of empirical and model angles of orientation of these boundaries has been carry out. It is shown that noncoincidence of Forbush effect observations and geomagnetic storms are the consequence of intersection geometry of solar wind disturbance regions by the Earth.

S5-01

TRAVELING CONVECTION VORTICES – CHARACTERISTICS AND ORIGINS

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Isolated and repetitive transient events with durations ranging from 5 to 20 min are common in high latitude dayside ground magnetograms, and associated riometer, optical, and VLF observations. They have been interpreted as evidence for the magnetospheric response to abrupt variations in the solar wind dynamic pressure, impulsive penetration, bursty reconnection on the dayside magnetopause, and the Kelvin-Helmholtz instability. Event characteristics and analytical models can help us distinguish between these possibilities. They are most obvious during quiet geomagnetic intervals (IMF $B_z > 0$ and low Kp) and at pre-noon local times, where they can reach amplitudes of up to several hundred nT. Peak amplitudes occur on magnetic field lines that map to magnetospheric locations at or Earthward of the inner edge of the LLBL. Most events are global, can be associated with transient increases in the H component of equatorial ground magnetograms, and compressions at geosynchronous orbit. A small fraction of the events can be associated with abrupt variations in the solar wind dynamic pressure, although almost all can be associated with variations in the IMF orientation of one type or another. The events exhibit a weak tendency to occur for radial IMF orientations and no tendency to occur for high solar wind velocities. The distance between events moving with the magnetosheath velocity is much larger than the width of the LLBL and comparable to the dimensions of the dayside magnetosphere. An unknown fraction of the events can be organized into equivalent ionospheric current systems with the appearance of single or double traveling convection vortices moving azimuthally around the auroral oval. Most events move antisunward, a small fraction move sunward, and there are indications that the sense of IMF B_y controls their speed. Whatever their origin, the events probably play a minor role in the solar wind-magnetosphere interaction.

S5-02

MULTIPOINT OBSERVATIONS OF TRANSIENT SOLAR WIND-MAGNETOSPHERE INTERACTIONS

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Several case studies suggest that geosynchronous magnetometers record clear signatures corresponding to impulsive events in high-latitude ground magnetograms. We present results from a statistical survey of geosynchronous signatures at the times of impulsive magnetic events identified in high-latitude magnetic field observations during 1986 and 1995 – 1998.

We use the high-time resolution geosynchronous observations to determine the dimensions and direction of event motion, and compare our statistical results with those predicted by various models for transient solar wind-magnetosphere interaction. We employ geosynchronous magnetic field observations to discriminate between the models of *Glassmeier* [1992] and *Southwood and Kivelson* [1990] for traveling convection vortices (TCVs).

We present observations indicating that transient solar wind variations can both initiate and terminate long-period geomagnetic pulsations. Magnetospheric expansions can result in a sharp cessation of VLF emission intensity recorded on the ground. We present the results of several case studies describing the different ULF, ELF, and VLF wave responses to the various categories of events seen at geosynchronous orbit during transient magnetospheric compressions and expansions.

S5-03

SIGNATURES OF TRAVELING CONVECTION VORTEX (TCV) EVENTS IN THE MAGNETOGRAMS FROM THE EQUATORIAL ELECTROJET (EEJ) REGION

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Traveling convection vortices (TCVs) are a clearly identified transient events in high latitude geomagnetic observations. They travel eastward or westward at geomagnetic latitudes near 72 to 74 degrees. Many causes have been proposed for TCVs, including bursty reconnection, pressure pulses, impulsive penetration and the Kelvin Helmholtz instability. Each cause can launch the compressional and shear Alfvén mode waves into the magnetosphere and ionosphere that are required to produce the events. *Zesta et al.* (*JGR*, 1999) provide an extensive analysis of the high latitude morphology and propagation characteristics of a traveling convection vortex (TCV) that occured on November 9, 1993. We report evidence for corresponding signatures at Belem (1.4 S, 48.8 W, dip 6.0), So Luis (2.6 S, 44.2 W, dip -0.6)and Teresina (5.1 S, 42.7 W, dip -6.5) under the equatorial electrojet (EEJ) band current. We also found clear signatures at Brazilian equatorial stations for several other TCV events identified in the geomagnetic observations of high latitude North American magnetometer arrays like MACCS and CANOPUS. A study of TCV events from the geomagnetic records in the Brazilian EEJ region is presented in this paper. The results suggest that transient waves reach the equatorial ionosphere by propagating across the geomagnetic lines of force.

S5-04

THE FIELD-ALIGNED CURRENTS OF TRAVELING CONVECTION VORTICES: FAST SPACECRAFT AND GROUND OBSERVATIONS

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On July 25, 1997 at $\sim$1840 UT a strong transient perturbation, a traveling convection vortex, occurred at the ground magnetograms of the MACCS, CANOPUS, and Greenland magnetometer chains. At the time of the TCV event on the ground FAST is crossing from the polar cap into closed field lines around 1846 UT and its footprint is moving over the Greenland stations mostly from north to south. There is also excellent solar wind and magnetosheath spacecraft coverage. Geotail, Interball and Imp 8 are in the morning solar wind, with Geotail being close to the bow shock and in the foreshock region. WIND is at the dusk magnetosheath. The perturbation on the ground consists of a series of about 3 cycles of peaks and bays with a period of $\sim$10 min. Ground magnetometer data indicate both a poleward and eastward propagation. FAST observes a series of intermittent particle precipitation signatures in the region of the LLBL and then a series of upward/downward field-aligned currents while flying through the region of the currents of the TCV. We determine the two-dimensional ionospheric current patterns from the ground magnetometers and correlate the location and strength of these currents with the current and particle signatures observed by FAST.

S5-05

VARIATION OF HIGH-LATITUDE IONOSPHERIC CURRENTS IN RESPONSE TO SOLAR WIND AND/OR IMF VARIATIONS

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We examine temporal variations of the geomagnetic field observed at several Greenland sites, and try to relate them to variations of the solar wind and interplanetary magnetic field which were observed with spacecraft located in the interplanetary medium. Particular attention is paid to the dayside high-latitude ionosphere, poleward of the auroral oval. We investigate the spatial and temporal scale size of the response of the ionospheric currents to changes in the interplanetary medium.

S5-06

TRAVELING CONVECTION VORTICES: OBSERVATIONS AND A MHD MODEL COMPARED

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Recently, a global 3D MHD model has shown ionospheric responses to solar wind pressure pulses which are similar to traveling convection vorticies (TCVs) [*Slinker et al.*, 1999]. We compare observations of TCVs made with high latitude magnetometers to MHD simulations using the observed solar wind parameters. Large two-dimensional arrays of magnetometers are able to observe the two-dimensional formation and development of the ionospheric currents associated with transients such as TCVs. 3D MHD codes are now able to model features of the magnetosphere-ionosphere system on timescales of tens of seconds and spatial scales of hundreds to thousands of kilometers. Using solar wind observations from upstream solar wind monitors as inputs to the MHD model, we simulate the effects on the magnetosphere-ionosphere of transient changes in the solar wind pressure and IMF orientation. These transients typically produce vortical flows in both the simulations and the observed currents. We compare the simulations to observed large scale features such as vortex formation location, sense of rotation, and propagation direction and speed.

S5-07

SCENARIO COVERING ALL PHASES OF NIGHTSIDE CONVECTION BASED ON INTERPLAY BETWEEN ION DRIFT AND RECONNECTION PROCESSES

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The rate of transfer of magnetic flux into the nightside dipole-like region is a function of the field-aligned current (FAC) intensity and $N_t - N_d$, where N_t and N_d are the total number of plasma sheet ions on flux tubes in the near-Earth tail and just inside the dipole-like region. In addition, for slowly varying convection, the FAC intensity is a function of the magnetic flux in the tail. The above two relationships provide the basis for a scenario for convection. Convection bays and steady state occur if there is an ample supply of flux tubes with a small value of N_t in the near-Earth tail. The growth phase occurs when a major increase in dayside reconnection leads to an increase in the amount of tail flux, which in turn causes increased convection into the nightside dipolar region. The plasma sheet thins until the predipolarization phase starts (reconnection or some similar process). The reconnection provides magnetic flux with reduced N_t, and also produces a change in the field-aligned currents, both of which increase the dipolarization rate after electrical coupling with the ionosphere is established. At that time, either a pseudobreakup or a substorm onset will occur. The recovery phase is a convection toward a steady state, in which the plasma undergoes redistribution in latitude, local time, radial distance, and energy. It can be either fairly localized or magnetosphere-wide, depending on the changes that have occurred in the dayside reconnection rate.

S5-08

MAGNETIC IMPULSE EVENT: A DETAILED CASE STUDY OF EXTENDED GROUND AND SPACE OBSERVATIONS

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We present a detailed discussion of an extensive set of ground and spacecraft data that are used to elucidate the beginning, evolution, and termination of a magnetic impulse event (MIE) on June 6, 1997. Starting at approximately 1600 UT, dozen of ground magnetometers at the northern and the southern hemispheres observed this MIE. The MIE was accompanied by a traveling convection vortex (TCV) in both hemispheres. The TCV appears to have originated in the pre-noon magnetosphere (~10 MLT) and traveled eastward at $2 - 3$ km/sec (at the Earth's surface) across magnetic local noon. DMSP particle data indicate that the TCV originated in LLBL and traveled the boundary between LLBL and CPS. All-sky cameras and riometers observed structured particle precipitation during the passage of TCV. Search-coil magnetometers observed MIE-related Pc 1 bursts at 1607 UT when the TCV crossed magnetic local noon. The penetration of the vortex into the dayside ring-current region ($L \sim 6$) may cause Pc 1 bursts. Antarctic twin HF radars observed the successive signatures of the TCV near the termination of it around 1612 UT. Solar wind data showed no pressure pulse or discontinuity of IMF associated with the onset of MIE.

S5-09

TRANSIENT PLASMA FLOW RESPONSE TO SOLAR WIND DYNAMIC PRESSURE CHANGE AS OBSERVED BY SUPERDARN AND MAGNETOMETERS

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SuperDARN radars observed a counter-clockwise plasma flow vortex centered at 72° geomagnetic latitude in the 14 MLT meridian during initial 10 min of the geomagnetic sudden commencement (SC) on April 21, 1997. The ionospheric plasma flow vortex may be generated by an earthward magnetospheric plasma flow inside the subsolar magnetopause due to a solar wind dynamic pressure increase. Ground magnetometer data from the Greenland stations (14.5 MLT) indicate magnetic deflections consistent with the ionospheric plasma flow vortex. Magnetometer observations in the high latitude evening sector (IMAGE) and at the dayside dip equator (Ancon, Peru) indicate negative magnetic deflections consistent with the preliminary reverse impulse (PRI) of SC caused by a global DP2-type ionospheric current system. The flow vortex observed by SuperDARN is thus an afternoon part of the twin vortices associated with field-aligned currents predicted theoretically by *Tamao* (1964) during the PRI. On the other hand, plasma flow enhancement took place in the cusp, suggesting an enhanced reconnection triggered by the solar wind pressure pulse.

S5-10

OPTICAL AND SUPERDARN SIGNATURES ASSOCIATED WITH SC/SI

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It has long been known that sudden positive changes in solar wind dynamic pressure trigger the geomagnetic sudden commencement (SC). SCs drive magnetopause motion, ground magnetic pulsations, optical auroral enhancement etc. For the mechanism of an enhancement of optical auroras and plasma waves it has been expected that the sudden compression of the geomagnetic field triggers these phenomena via processes of instability in the equatorial plane filling the loss cone. On the other hand, the geomagnetic response to a sudden expansion of the magnetosphere is called negative geomagnetic sudden impulse (SI−). Our recent study showed that the negative SI also triggered the optical auroral pulsation, magnetic pulsation and HF backscatter power pulsation, and concluded that the luminosity pulsations triggered by the solar wind negative impulse are amplified not via processes of loss cone instability but via dynamic coupling between the solar wind, magnetosphere, and ionosphere. The aim of this paper is to apply whether a positive SC/SI can also trigger optical auroral enhancement via dynamic coupling between the solar wind, magnetosphere, and ionosphere. We acquired the unique data sets of solar wind parameters, optical aurora, magnetograms, and SuperDARN HF radars.

S5-11

FLUX TRANSFER EVENTS AND RELATED PHENOMENA

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I will present ground- and space-based observations of the convection and auroral response to transient phenomena occurring in the dayside auroral zone, focussing on the effects of non-steady magnetopause reconnection, or flux transfer events. Recent results obtained with the Polar UV imager and SuperDARN radars suggest that the overall scale-size of the reconnection region can be significantly larger than previously appreciated, and that this region moves across the magnetopause. The dynamics of the reconnection site may go some way towards explaining the quasi-periodic nature of auroral and convection signatures of transient reconnection.

S5-12

IONOSPHERIC CUSP FLOWS PULSED BY SOLAR WIND ALFVÉN WAVE COUPLING TO THE DAYSIDE MAGNETOPAUSE

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Pulsed ionospheric flows (PIFs) in the cusp footprint are believed to be a consequence of magnetic reconnection on the dayside magnetopause. PIFs are interpreted as ionospheric signatures of quasiperiodic flux transfer events (FTEs). However, the question of what causes pulsed reconnection has remained unanswered. Here the PIFs are correlated with Alfvénic fluctuations that were observed in the upstream solar wind. It is concluded that on these occasions the FTEs were pulsed by Alfvén waves coupling to the dayside magnetosphere. The cross-correlation analysis of the IMF and the ground magnetic field near the cusp footprint indicates time lags that are several minutes longer than the propagation time estimates computed from multipoint solar wind measurements. That is, there is a delay between the expected arrival of the Alfvén wave southward turning and the reconnection onset on the dayside magnetopause. We interpret the delay in terms of the intrinsic time scale for reconnection [1] and a model of surface-wave-induced magnetic reconnection [2]. I has been argued [2] that surface waves with wavelengths larger than the thickness of the neutral layer can induce a tearing-mode instability whose rise time would be the intrinsic timescale for the reconnection onset. The timescales inferred from theory [2] are similar to the observed delays.

[1] *Russell et al., Adv. Space. Res.*, **19**, 1913–1917, 1997.
[2] *Uberoi et al., J. Geophys. Res.*, **104**, 25153–25157, 1999.

S5-13

FIELD AND PLASMA PROPERTIES INSIDE AND VICINITY OF THE CUSP

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Both large-scale and meso-scale field properties are compared between solid dense cusps and patchy dispersed cusps (cleft) using Freja and Viking data. (1) The large-scale field-aligned currents in the dense solid cusp are separated from and independent of the dayside region 1 FAC outside the cusp. (2) Large-scale poleward convection is strongest at the east/west boundaries but not inside the dense solid cusp. (3) Meso-scale injections inside the dense cusp accompany deceleration of poleward convection, while meso-scale injections of the patchy cusp are sometimes accompanied by enhancement of the poleward convection. The result indicates that the dense cusp forms "extra" open region in the already-open magnetosphere, causing a blocking of the anti-sunward convection due to, *e.g.*, the mass loading effect of the ionospheric escaping ions.

S5-14

STATISTICAL AND CASE STUDIES OF DPY CURRENTS BASED ON ØRSTED SATELLITE AND POLAR GROUND-BASED OBSERVATIONS

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High-latitude ionospheric currents, the DPY currents, associated with the IMF B_y-component, are observed at the cusp/cleft region at approximately 75° invariant latitude at the dayside of the Earth. The DPY currents most often involve oppositely directed field-aligned current sheets bordering the cusp/cleft region. In the ionosphere these currents close through horizontal North-South directed Pedersen currents while the potential structure imposed by these currents drive transverse East-West directed convection flows and associated Hall currents which are detectable from ground through their magnetic effects. The presentation will focus on the correlation of field-aligned currents within and bordering the cusp region as detected by the high-precision magnetometer observations from the Ørsted satellite and the polar ionospheric convection and DPY ionospheric current systems detected from ground-based observations. Based on the high-energy particle observations from Ørsted it appears that the equatorward part of the field-aligned DPY currents is located on 'closed' field lines while the poleward part is on 'open' field lines. Statistical results are presented to illustrate the general distribution of DPY field-aligned currents in response to IMF conditions. Individual cases are analyzed to show that the ionospheric currents often reproduce IMF B_y variations in ground magnetic recordings over a large region while the associated field-aligned currents have complicated structures and large variability on small spatial and temporal scales.

S5-15

FIELD-ALIGNED CURRENT DISTRIBUTIONS OBSERVED FROM ØRSTED

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The Ørsted satellite is equipped with instrumentation for high-precision measurements of the Earth's magnetic field. The satellite is placed in a polar LEO, with the orbit plane drifting in LT at −0.9 min/day. Subtracting a Ørsted preliminary main magnetic field model, the residuals from the 3-axial magnetic field components over the northern and southern polar caps were used to obtain the field-aligned current distributions. The distributions reproduce the Region 1 and Region 2 current systems over dusk and dawn, as well as the NBZ cusp currents at the dayside. The results are compared with other available models of field-aligned current distributions over the polar regions.

S5-16

AN INVESTIGATION OF IMPULSIVE TRANSIENTS IN THE HIGH-LATITUDE IONOSPHERE USING THE SOUTHERN HEMISPHERE IMAGING RIOMETER

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We explore the dynamics of patches of enhanced cosmic noise absorption (CNA) observed with an imaging riometer to occur concurrently with large impulses seen in ground-based magnetograms in the dayside polar regions. The use of imaging riometry enables determination of the propagation velocity and direction of the localized convection disturbances associated with these magnetic impulses (or MIEs), as well as observation of the time-varying structure of the related CNA patches. The convection disturbance inferred from the motion of such patches is explored in relation to the estimated magnetic field topology derived from FAST satellite data and observations of magnetic field-line resonance signatures. Of particular interest is the ionospheric motion of MIEs in the vicinity of the southern polar cusp region. The dynamics and morphology of a large number of impulsive magnetic events have been studied in this way using the recently installed SHIRE imaging riometer at Davis station in Antarctica along with collocated fluxgate magnetometer data, and the results provide some insight into the much debated MIE generation and propagation mechanisms. Such observations enable further refinement of the characterisation of MIEs by their ionospheric propagation characteristics, and riometer signature.

S5-17

SOLAR WIND DEPENDENCY OF THE AURORAL ELECTROJET AS OBSERVED WITH THE ØRSTED SATELLITE DURING THE SEPTEMBER 1999 SPACE WEATHER MONTH

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The high accuracy of the magnetic measurements and good stability of the instruments of the Ørsted satellite make it possible to determine at the altitude of the satellite the small contributions from the horizontal ionospheric currents, for example from the auroral electrojet. A technique has been developed based on the measurements of the absolute value of the magnetic field, which provides for each polar crossing individually (*i.e.*, every 50 minutes either North or South) the intensity and distribution of the east-west going ionospheric currents along the orbit. The ionospheric currents derived from the satellite data not only correlate very well with the ground based AE-index but in addition provide information on the latitudinal position and extension of the electrojet currents as well as other observed current systems. As an advantage over the ground based magnetic data, the satellite data do not have as much a problem with the determination of baselines (the need to determine quiet day levels) because with Ørsted we have an accurate model of the main field.

Here, we present the results of applying this technique to Ørsted data with main emphasis put on the findings during the S-RAMP Space-weather month of September 1999. Orbit by orbit we can follow the large-scale evolution of (mainly) the westward electrojet both in the Northern and Southern hemisphere in the near noon and midnight sectors of the satellite orbit. The main features hereof, including some large inter-hemispherical differences in the behavior, will be discussed with special emphasis on their relation to the interplanetary magnetic field and plasma density and flow speed of the solar wind.

S5-18

POLAR CAP AND AURORAL OVAL DYNAMICS DURING 22 – 24 SEPTEMBER, 1998

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This paper describes the polar cap and auroral oval dynamics during September 24 – 27, 1998 geomagnetic storm. Storm's onset was accompanied by a compression of the dayside magnetopause after the arrival of the impulse in the solar wind. During the first 30 minutes of the dynamic pressure impulse, the entire auroral oval became active and the polar cap shrank to less than 1/2 the its size before the start of the event. Auroral oval was bright and thick, especially at the nightside. The activation of the main phase of the storm began in the second hour on 25 September, 1998. The interplanetary magnetic field turned steadily southward and the entire oval moved equatorward. The auroral oval became thin and the polar cap area increased by more than factor of 3. During the recovery of the main phase of the storm, the aurora became gradually less active. Ultraviolet images for the remainder of the storm recovery period typically show quiet to extremely quiet aurora. In the present paper we interpret the observed behavior of the polar cap and auroral oval during this space weather disturbance.

S5-19

IONOSPHERIC ELECTRODYNAMICS RESPONSE TO THE SOLAR WIND VOID OF 10 – 12 MAY 99

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Disturbances in the solar wind, especially large structures such as magnetic clouds and their associated geomagnetic storms, have been the focus of much recent scientific investigation. On the opposite end of the spectrum are geomagnetic responses to near voids in the solar wind. Such a solar wind void passed the earth between 10 and 12 May 1999. We use the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) procedure to produce maps of high-latitude ionospheric parameters in both hemispheres for 11 May 1999. Our maps of convection, Joule heating, particle precipitating power and field-aligned current show a striking asymmetry between hemispheres. Within the northern hemisphere the patterns show electrodynamic interactions focused on the polar cap and extending to roughly 70 MLAT. A single convection cell dominates in the northern hemisphere. In the southern hemisphere the convection is broader and generally more diffuse. While the cross-polar voltages are similar between the hemispheres (35 kV in the north and 43 kV in the south), there is at least a factor-of-five difference in the interhemispheric strengths of field-aligned currents, Joule heating and particle precipitation power. The northern hemisphere polar cap particle precipitation is the strongest we have ever mapped. In the northern hemisphere intense electrodynamic interactions were focused above 70 magnetic latitude. In the southern hemisphere only weak, irregularly structured patterns result from the data assimilation. We attribute these differences to the strong interplanetary magnetic field spiral configuration, the sunward tilt of the dipole field and the direct beam or "strahl" of solar coronal electrons impinging on the northern polar cap during the momentum void.

S5-20

A LINKAGE BETWEEN POLAR PATCHES AND PLASMASPHERIC DRAINAGE PLUME

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Two distinct features may follow the same convection pattern: polar ionization patches and the plasmaspheric drainage plume. Polar patches are regions within the polar cap where the F-region electron concentration and airglow emission at 630 nm are enhanced above a background level. Observations from Millstone Hill incoherent scatter radar [*Foster*, 1993] suggested that polar patches were formed by the mechanism in which plasma initially corotates past noon at lower latitudes, before being entrained in the convection pattern in the afternoon sector, and brought back toward noon. During an increased magnetospheric convection, the flux tubes loaded with cold and dense plasmaspheric material were observed to follow the newest open trajectory and drain toward the dayside magnetopause, known as the plasmaspheric drainage plume. This study is to map the enhanced electron concentration observed from Millstone Hill radar to the equatorial plane and compare the trajectory with the drainage plasmasphere observed from the geosynchronous satellite for the storm event on March 1990. The result shows that both F-region electron concentration and drainage plasmasphere follow the newest seperatix (the boundary between open and close drift trajectory) convecting sunward. Observations have shown that the polar patches were transported over the polar cap into the night side. Hence, we believe that the drainage plasmasphere should follow a similar trajectory transporting plasmaspheric material over the polar cap into the tail.

S5-21

LARGE-SCALE IONOSPHERIC FLOWS AND THEIR RESPONSE TO VARIATIONS IN THE INTERPLANETARY MEDIUM

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The dependence of the pattern of high-latitude plasma convection on the properties of the solar wind plasma has been amply demonstrated in numerous statistical studies. With the advent of more comprehensive sets of direct velocity measurements the evolution of the global pattern between quasi-static states during periods of changing IMF can now be studied definitively. Several groups of researchers have described the response to sudden IMF changes as globally coherent and nearly simultaneous on time scales of minutes. Aspects of this interpretation are in dispute. In this presentation we examine periods of extensive observations with the SuperDARN network of HF radars to more fully characterize the ionospheric response. We find that the response can be detected in ionospheric parameters in addition to the point-by-point velocity measurements, including the occurrence of HF backscatter and the latitude of the equatorward boundary of the convection zone. Many cases point to a nearly simultaneous onset of effects on global scales. Following onset, we are able to distinguish different time constants for the emergence of new features in the convection. For example, in cases of northward turning of the IMF, sunward flow on the noon MLT meridian may be established in a few minutes while flow on the flanks evolves on time scales of tens of minutes. Generally, we do not observe a simple linear progression from an initial to a final state following a strong IMF change. We discuss these results, the physical implications of nearly simultaneous onset in convection effects, and the causes of nonlinearity in the global evolution of the pattern.

S5-22

LARGE-SCALE CONVECTION RESPONSE TO IMF B_Z CHANGE – A POLAR CAP ARC STUDY

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We investigate the large-scale convection change due to a transition from positive to negative IMF B_z. Positive B_z facilitates lobe reconnection and gives rise to a four-cell convection pattern in the ionosphere, while B_z-negative favours subsolar reconnection and results in two cells.

Polar cap arcs can appear in the shear zones of the convection cells during B_z-positive conditions, even though examples of arcs co-existing with substorms, a typical phenomena of negative B_z, have been found.

We show an example of a polar cap arc whose dynamics reveal the convection change due to a transition from positive to negative B_z, while B_y is mainly positive throughout the event. In this event, the 22nd of January 1999, Polar UVI showed a transpolar arc that had been established during the previous, calm B_z-positive period and stretched across the whole auroral oval.

At the B_z change subsolar merging started to alter the convection, which was clearly monitored by the northern hemisphere SuperDARN radars and magnetometer networks. The arc was now "erased" from the dayside towards nightside, as the convection pattern in the ionosphere evolved towards a B_z-negative state. While this occurred the arc also rotated clockwise toward dusk, governed by the B_y component. As soon as the arc had disappeared, the energy loading during subsolar merging led to an intense substorm, whose signatures could be detected both in mid-tail and near-Earth regions.

S5-23

NON-LOCAL RESPONSES IN IONOSPHERIC CONVECTION TO SOLAR WIND EFFECTS

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The wider distribution of ground-based instrumentation and increasing coverage of satellite data means that more of the magnetosphere can be observed simultaneously. What were once just thought to be local phenomena confined to a limited range in latitude and longitude have now been found to have more global significance. For example, flux transfer events at the dayside, *e.g. Greenwald et al.* (1999) lead to nearly instantaneous responses in the total ionospheric convection, and the formation of the substorm current wedge at substorm onset has a corresponding fast response in the dawn and dusk electrojets, *Boralv et al.* (2000). A merged data set of CANOPUS and MIRACLE magnetometer stations is employed to conduct a search and three-year statistical study of such non-local behaviour in the magnetosphere. This is in effect combining two meso-scale networks to form a global network. Case examples are compared to signatures in ground-based radars and the solar wind forcing conditions for each type of behaviour is investigated.

S5-24

GLOBAL IONOSPHERIC RESPONSE TO INTERPLANETARY MAGNETIC FIELD CHANGES

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We demonstrate a global, nearly simultaneous increase of ionospheric convection and horizontal magnetic perturbations following a sudden southward IMF turning on November 24, 1996, based on the SuperDARN radar and ground magnetometer data. The AMIE-derived convection patterns, especially the residual convection patterns, show clearly coherent development of a two-cell convection configuration. The most important feature to notice is that, while the residual convection intensifies with time, the foci of the residual convection cells remain nearly steady. There is no evidence of dayside to nightside propagation in the evolving convection patterns.

S5-25

RECONFIGURATION TIMESCALES OF DAYSIDE IONOSPHERIC CONVECTION

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Changes in ionospheric flow patterns provide direct observations of how the magnetosphere-ionosphere system is coupled to the IMF. The nature and location of reconnection on the magnetopause is communicated to the ionosphere which responds by reconfiguring global convection patterns. The dynamics of the changing global ionospheric convection patterns can be observed using a large two-dimensional array of ground magnetometers. We have found that for certain sharp reorientations of the IMF, dayside ionospheric convection patterns may globally reconfigure themselves in timescales as short as 8 minutes. For some types of IMF reorientations this time required to transition from a pre-existing convection state to a new one is found to be a function of local time. IMF B_z northward to southward transitions have reconfiguration times near local noon of approximately 6 minutes and lengthen approximately 2 minutes for every 3 hours of local time away from noon. This local time dependence is similar for IMF B_z southward to northward transitions, but with longer overall reconfiguration times with the shortest at local noon of about 10 minutes. For IMF reorientations dominated by IMF B_y this local time ordering does not appear to be present; the reconfiguration takes place at nearly the same rate at all local times (on the dayside) with a reconfiguration timescale of about 8 minutes.

S5-26

MHD MODEL RESULTS OF THE MAGNETOSPHERIC RESPONSE TO IMF DISCONTINUITIES: THE EFFECTS OF LOWERING THE INNER MAGNETOSPHERIC ALFVÉN VELOCITY

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We examine MHD simulation results of the magnetospheric and ionospheric response to discontinuities in the interplanetary magnetic field (IMF) orientation. It has been shown that the ionosphere has a rapid global response to changes in the merging between the IMF and the magnetospheric field lines. One proposed mechanism for this rapid response is the extremely fast Alfvén wave speed in the near-Earth magnetosphere. Because of this large Alfvén speed, the time step in MHD simulations is very small. One way to bypass this small time step is to effectly reduce the Alfvén speed. This allows a much larger time step to be taken, and therefore more time to be modeled. We investigate the ramifications of this by modeling the magnetospheric and ionospheric response to IMF discontinuities with and without the lowered Alfvén velocity.

S5-27

EVOLUTION OF CUSP PLASMA FLOW AND LARGE-SCALE CONVECTION VORTEX

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Contribution of ionospheric plasma flows in the day-side cusp to development of the large-scale convection electric field was investigated by applying the APL convection map model [*Ruohoniemi and Greenwald*, 1998] to the SuperDARN observation in the wide local time range (10 – 22 MLT) at 18 – 20 UT on November 17, 1996. The magnetic field data from the CANOPUS and West Greenland magnetometer arrays are used for identifying the timing of convection flow changes. During the period of the northward IMF, a small-scale twin vortex was observed at higher latitude (78° – 83° geomagnetic latitude) of the cusp region in the 10 – 14 MLT sector in addition to large-scale convection vortex centered in the 18 – 20 MLT sector. The twin vortex consists of a clockwise vortex in the pre-noon and counter-clockwise one in the post-noon, indicating cusp field-aligned currents. The large-scale convection vortex was intensified with a center in the 15 – 16 MLT sector at 78° – 80° magnetic latitude after the IMF turned southward. We found that the small-scale twin vortex in the cusp region remained for 4 minutes after the onset of the development of large-scale convection vortex. Three-dimensional global MHD simulation of Earth's magnetosphere for this event shows that the small-scale twin vortex in the cusp region coexists with the newly reconnected magnetic flux transfer for a few minutes.

S5-28

CHARACTERISTICS OF IONOSPHERIC CONVECTION OBSERVED BY SYOWA EAST/SOUTH SUPERDARN RADARS DURING MAY 10 – 13, 1999

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Ionospheric convection during May 10 – 13, 1999 has been studied by using the HF radars in the southern hemisphere, when the solar wind density is very low (up to < 0.1 /cc). The echo regions observed by Syowa East/South SuperDARN radars were located several degrees poleward of the averaged location. On the other hand, the radars observed very high (> 1000 m/s) plasma flows directed from the nightside toward the dayside. This high-speed flow was observed across the fields of view of Syowa East and Syowa south radars from 1530 to 2400 UT on May 11, when the solar wind density was close to minimum and the IMF was constantly northward. The comparison with the DMSP particle data shows that the westward flow regions were collocated with the auroral oval. Possible mechanisms for generating this fast flow will be discussed.

S5-29

EFFECT OF INTERPLANETARY MAGNETIC FIELD ON EQUATORIAL IONOSPHERE

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The daytime characteristics of the equatorial ionosphere are analysed with the aim to prove effect of interplanetary magnetic field on equatorial ionosphere. It can be shown that this effect is the result of direct penetration of field-aligned currents (FAC) to equatorial ionosphere. It is demonstrated that the counterelectrojet (CEJ) events are accompanied by the increase of critical frequency foF_2 and by the decrease F-region vertical plasma drift. The increasing of the equatorial electrojet (EEJ) is associated by the foF_2 decreasing and the F-region vertical plasma drift increasing. The model of direct penetration of the FAC from the polar Region 1 and 2 (R1, R2) to the equatorial ionosphere is presented to account such phenomena. The R1 FAC associated with IMF $B_z < 0$ close across the equatorial ionosphere and flow cocurrent with EEJ. The EEJ is increased by the R1 FAC and we can see foF_2 decreases at equator. Counterelectrojet and its effect on equatorial F-layer is associated with the R2 FAC ($B_z > 0$).

S5-30

IMF-DEPENDENT POTENTIAL MODEL HAVING SPACE-WEATHER APPLICATIONS

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To forecast high-latitude plasma convection and current distribution, or space weather, from satellite measurements in the upstream solar wind, a method has been developed to derive the electric potentials in the polar ionosphere obtaining from any combination of the IMF orientation and magnitude, and solar wind velocity. Potential data obtained from electric field for all polar passes of DE 2 (from 08/81 to 02/83) were analyzed. Analysis was focused on the magnitude and location of the potential extreme points and the location of zero potential for each DE 2 pass. These potential parameters were examined for available passes (about 2700) selected with appropriate criteria. More than 80 % of the passes occurred at nonsubstorms, and the potential parameters from these nonsubstorm passes were sorted with IMF Y/Z angle. The parameters in each group were examined in relation to the solar wind parameters such as magnitude of IMF in the $Y - Z$ plane, B_z, and solar wind speed. With obtained relations for the peak and zero potentials a whole two-dimensional potential pattern has been constructed by cubic spline interpolation. Our potential distribution gives stronger flow in the polar cap for northward IMF than other convection models, and our convection seems to fit to the observation better. Our convection around the midnight local time has been also found to be stronger for substorm cases which were obtained by the modification of the nonsubstorm cases with DE 2 substorm passes. Detailed comparison between our model and observations corresponding to similar solar wind conditions will be presented for the convection together with the field-aligned current distribution derived from the convection pattern with appropriate conductance model.

S5-P01

RELATION OF THE IONOSPHERIC CONVECTION TO THE SOLAR WIND PARAMETERS

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We have processed electric field observations detected by the Dynamics Explorer 2 satellite and obtained several hundred values of the electric potential difference between the dawn and dusk sides of the polar cap. Hourly-averaged solar wind parameters and geomagnetic indices have been used for studying statistical relations. The potential difference appeared to depend on the IMF southward component and solar wind velocity both for the current and previous hour. The growth of the magnetic storm-time depression linearly depends on the potential difference.

S5-P02

PROPAGATION VELOCITIES OF GEOMAGNETIC SUDDEN IMPULSES CAUSED BY SHARP CHANGES OF SOLAR WIND DYNAMIC PRESSURE AT HIGH LATITUDES

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Here we consider the propagation along the Earth's surface of sudden disturbance impulses SC and SI of the geomagnetic field caused by sharp changes of the solar wind dynamic pressure P_d. The world network magnetometer data in the northern hemisphere in the range of corrected geomagnetic latitudes 55 deg to 85 deg separately for cases of the P_d increase and decrease have been analyzed. The impulse propagation velocities in azimuth and meridional directions have been calculated and their dependence on latitude and local magnetic time has been obtained. Regularities of SC and SI propagation during the increase and decrease of the solar wind dynamic pressure are similar in general, excepting the fact that during the increase of P_d the velocities both in meridian and in azimuth are noticeably higher than during the P_d decrease. In both cases the disturbance impulses are propagated northward and in the considered latitude range their velocity in this direction decreases as the latitude increases. The azimuth velocity increases as the impulses move from the midday hours to the morning and evening sectors. One can explain the obtained results by means of changes of the picture of high-latitude convection defined by conditions in solar wind and ionosphere during the period of sudden impulses.

S5-P03

NON-STATIONARY RECONNECTION IN REGION OF LOW LATITUDE DAWN MAGNTOPAUSE DETECTED BY INTERBALL-1

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It is shown that chain of unusual discontinues observed by Interball-1 in the dawn magnetosheath is connected with propagation of sector boundary of IMF (analysis of ground magnetogramms). Interball magnetic field data (B) during the event are analysed by MGM spectral method. MGM is capable of making a self-consistent selection of trends from a data set and singling and out harmonics with varying phase and amplitude. The non-stationary waves at period $T = 124 \pm 30$ sec ($f \sim 8$ mHz) has the largest amplitude (after trend) in the spectrum. Other non-stationary waves are in the spectrum too. Spectrum of electron density n_e has $T \sim 16 \pm 0.5$ min. ($f \sim 1$ mHz), $T \sim 170$ sec. ($f \sim 6$ mHz) and other T. Close periods present in spectrum of electron temperature T_e. Our studies of the time changes of the projections of the magnetic field directions on XY, YZ, XZ planes (GSM) shows a formation of the stationary wave structure with $|B| \sim 0$ and high density heated plasma that is located in front of the magnetopause. When the IMF sector boundary reaches the region close the magnetopause the 20-min stationary variations of Te and ne exist (it is seen from analysis of ground magnetogramms). Following process of non-stationary magnetic reconnection in the magnetopause region with period $T \sim 124$ sec. in B is determined by the stationary variations at $T \sim 20$ min. A regime of non-stationary oscillations (damping or building-up) depends on phase of stationary variations at $T \sim 20$ m. Analysis shows that Interball detected two fast shock waves propagating upstream and downstream through antisunward and sunward plasma flow accordingly and non-stationary waves connected with the reconnection in the studied region.

S5-P04

THE DISTENTION OF THE MAGNETOSPHERE ON MAY 11, 1999: HIGH LATITUDE ANTARCTIC OBSERVATIONS AND COMPARISONS WITH LOW LATITUDE MAGNETIC AND GEOPOTENTIAL DATA

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In this presentation, we examine the Earth's ionospheric response on 11 May 1999 to an unusually tenuous solar wind, focusing on magnetometer, riometer, and optical data from high geomagnetic latitudes in Antarctica. These observations complement northern hemisphere studies, and provide a global context in which to study this event. Comparisons are made with data taken from the HYDRA and PIXIE instruments onboard the POLAR satellite during a brief perigee pass over Antarctica on May 11, and with geomagnetic data collected from the polar cap to low latitudes. It will be shown that the southern hemisphere was geophysically active, even though the Kp index on May 11 ranged only from 0 to 0+. Furthermore, despite the fact that the IMF and solar wind conditions favored northern hemisphere polar rain, 630.0 nm emission was observed throughout most of the day at high latitudes over Antarctica. Geomagnetic power levels derived from data taken at low, cusp, and polar cap latitudes also showed that magnetic power throughout the Earth on May 11 was lower than on surrounding days. Although this might be expected, discrete peaks in ULF power were still evident at these stations, especially at South Pole, and variations in power levels as a function of frequency existed between observing stations. The relationship(s) and correlations between power, frequency, and latitude will be discussed.

S5-P05

THE RELATIONSHIP OF VLF EMISSIONS, RIOMETER ABSORPTION, AND AURORAL LUMINOSITY TO THE MAGNETIC SIGNATURES OF MAGNETIC IMPULSE EVENTS (MIEs)

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High latitude, ground-based observations provide the opportunity to investigate phenomena occurring at the dayside magnetopause and magnetospheric boundary layer because the dayside cleft/cusp represents the ionospheric projection of these regions. Magnetic impulsive events (MIEs) are one type of transient, small scale phenomenon observed on the dayside. Such events have been interpreted as traveling convection vortices (TCVs) due to their tailward-moving vortex-like Hall current flow patterns. Although there have been numerous MIE and TCV studies, many have concentrated on only one or two signal characteristics, most often the magnetic perturbation. Information on electron precipitation, if presented, is usually in the form of auroral images or photometric data. This paper examines the relationship of precipitation to the magnetic signatures of several MIEs employing VLF, riometer, and auroral observations. It will be shown that even when precipitation is sensed by riometer and/or optical methods, VLF emissions can be rather different between MIEs. Some MIEs exhibit VLF wave energy mostly below 10 kHz, while others cover a broader frequency range, and most are different from typical impulsive auroral hiss. Taken together, these multi-instrument observations can help identify the relevant MIE mechanism(s) and correctly place their location and source in space.

S5-P06

THE IONOSPHERIC CUSP'S RESPONSE TO A SHARP SOUTHWARD TURNING OF THE IMF: A CASE STUDY

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We present a midday auroral breakup event associated with a sharp southward turning of the IMF (interplanetary magnetic field) that occurred on January 21, 1999. On this day, a well-defined northward-to-southward IMF transition hit the magnetosphere when the European meridian was in the noon sector. Using the UK twin HF radars (CUTLASS) and optical observations at Ny Aalesund, we have investigated the ionospheric cusp's response to the sharp IMF change. The first ionospheric signature of the IMF transition starts about 2.5 minutes after its arrival at the subsolar magnetopause. This signature is found at high latitudes (80 – 85 magnetic) in the postnoon sector, and in this meridian some indication of equatorward cusp motion is observed. However, the changes at this stage are not so conspicuous. The major ionospheric flow change starts 3 minutes after the first signature, at lower latitudes (77 – 80 magnetic) in the prenoon sector. This activity expands into the noon meridian with time, and is characterized by fast (> 800 m/s) poleward and eastward flows as often interpreted as ionospheric signatures of flux transfer events. On the basis of these observations, we discuss the timescale of the magnetosphere-ionosphere coupling associated with dayside flux transfer events.

S5-P07

RESPONSE OF THE AFTERNOON CONVECTION CELL TO AN IMF SOUTHWARD TURNING

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One example of the global dynamics of ionospheric convection has been studied by using the SuperDARN radar network when the IMF suddenly changed from northward (+6 nT) to strongly southward (−19 nT), at 1716 UT on September 5, 1995. The B_z component was fairly constant for about 2 hours and about 27 min before and after the time of change. There were two-step changes in the ionospheric flow pattern. First, the radar in the late morning sector, observed a sudden transition in the flow direction from equatorward to poleward, and then an equatorward shift of the cusp scatter region. This change propagated to the fields of view of other radars in the afternoon/evening sectors within the time delay of less than 2 minutes. Simultaneously the dayside ground magnetograms in the cusp latitude observed the sudden change of the equivalent current vector from poleward to equatorward, and the corresponding changes were also recorded by the high latitude magnetic stations in other local time sectors almost at the same time. The DMSP particle data showed an equatorward expansion of the auroral oval in the 21 MLT sector shortly after the first response. About 10 to 20 minutes after the first change, equatorward expansion of the current reversal boundary observed by the magnetometer chain in the dusk sector occurred, as well as the equatorward expansion of the convection reversal boundary at the radars in the afternoon/evening sectors. These observations indicate that there were two kinds of responses in ionospheric convection to the southward turning of the IMF. We speculate that the first response is associated with the propagation of magnetosonic waves, and that the second response is consistent with the *Cowley and Lockwood* [1992] picture of the redistribution of the newly created open flux in the polar cap region.

S5-P08

THE RELATIONSHIP BETWEEN THE LATITUDINAL LOCATIONS OF THE AURORAL ELECTROJETS AND THEIR CURRENT DENSITY

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AE indices have been extensively used in various solar-terrestrial physics since their introduction to the community. Recently it has been reported that the *AE* indices do not properly monitor the auroral electrojets because they expand equatorward beyond the standard *AE* network as magnetic activity increases. It is particularly the case with the westward electrojet. Such a discrepancy is more serious than the one associated with the longitudinal *AE* station gaps. Thus the latitudinal standardization of the *AE* indices as function of magnetic activity is highly desirable. To determine quantitatively the equatorial expansion of the auroral electrojets, we analyze extensive database obtained from the Alaska meridian chain, Greenland chain and IMAGE chain of magnetometers. These chains of magnetometers enable us to determine the latitude where the auroral electrojets with maximum current density flow. Also examined is the local time dependence of the equatorial expansion. For this purpose we employ the flexible tolerance method proposed by *Sun et al.* (1993). Based on the relationship thus obtained, it is attempted to standardize *AE* indices.

S5-P09

CME EFFECTS ON IONOSPHERIC CONDITION

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There are many kinds of ionospheric disturbances connected with solar phenomenon. One of them is the critical frequency of F2-layer (f0F2) deviation (Df) of mean value. Analysis of the data of vertical ionospheric sounding received at the Zimenki observatory (near Nizhny Novgorod) during periods of 1980, 1984, and 1985 were carried. Appearance of ionospheric disturbances Df is associated with the registration of the Coronal Mass Ejection. Effect of the features of CME on Df is presented. This work is supported by Russian Foundation for Fundamental Research (grant No. 00-02-17655) and the Russian Federal Programme "Astronomy".

S5-P10

PLASMA WITHIN AN IMF-B_Y RELATED POLEWARD PROGRESSING MAGNETIC DISTURBANCE: EISCAT SVALBARD RADAR OBSERVATION AND TRANSCAR SIMULATION

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On March 03, 1999, the EISCAT (European Incoherent SCATter) Svalbard Radar (ESR) was observing the dayside high-latitude ionosphere when a sudden change of the Y-component of the Interplanetary Magnetic Field (IMF) occurred. Ground magnetometers recorded a strong magnetic disturbance of the X-component indicating a reversal of the zonal plasma flow and therefore a reconfiguration of the ionospheric convection cells.. They also reveal a clear poleward motion of this magnetic disturbance indicating that the effect of the IMF change propagates from the cusp latitudes up to the polar cap. ESR, ideally located, saw the disturbance pass through its field of view. The plasma within this disturbance as seen by ESR has high ion temperature. A simulation of such a flow reversal has been performed in order to understand how the ionosphere reacts to a IMF B_y change and more specifically, to explain this local ion heating associated to the moving magnetic disturbance.

S5-P11

THE TIME DELAY IN THE CAUSAL ANALYSIS OF EQUATORIAL IONOSPHERIC PROCESSES

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Responce of the critical frequency foF_2 on electric field variations during magnetic storms is analysed. The time lag has to be taken into account when causal analisis of ionospheric processes is carried out. It is shown that the critical frequency foF_2 starts to drop about an hour after enhancement of convection of the equatorial electric field caused by the IMF $B_z < 0$. Variations of foF_2 intensity depend from the IMF B_z and the equatorial electric field magnitude. The electric fields from Region 1 and Region 2 penetrate to equatorial ionosphere almost instanteneously and correlate with the H-component of geomagnetic field. The time lag between IMF B_z, equatorial electric field and foF_2 makes possible to predict IMF B_z associated variations of foF_2 practically for 1.5 hours forward, taking into account time delay of the polar electric field to the IMF B_z.

S5-P12

DETERMINATION OF THE IONOSPHERIC CONVECTION ELECTRIC POTENTIAL BASED ON SUPERDARN VELOCITY MEASUREMENTS

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The area in the high latitude ionosphere where measurements of the convecting plasma are made has been significantly extended with the addition of two radars to the existing network of six Super Dual Auroral Radar Network (SuperDARN) HF radars in the northern hemisphere. Periods are now common during which velocity measurements are available over nearly 3/4 of the high latitude region. We show that during such periods the distribution of the electrostatic potential, Φ, associated with the '$\boldsymbol{E} \times \boldsymbol{B}$' drift of ionospheric plasma can be reliably mapped on global scales. The global electrostatic potential maps, or the equivalent convection maps are solved using an established technique of fitting velocity data to an expansion of Φ in terms of spherical harmonic functions. When the measurements are extensive, and especially when they span the region between the extrema in the potential distribution, the solution for the global pattern becomes insensitive to the choice of statistical model data used to constrain the fitting. That is, the statistical model data then only guide the solution in regions where no measurements are available, and the details of the model data have little effect on the gross features of the large-scale convection patterns. The resulting total potential variation across the polar cap, Φ_{PC}, is virtually independent of the statistical model. The ability to accurately determine Φ_{PC} and the global potential, Φ, based on direct measurements is an important step in understanding solar wind-magnetosphere-ionosphere coupling.

S5-P13

IONOSPHERIC CONVECTION FROM THE GLOBAL MHD SIMULATION ON THE EVENT ON NOVEMBER 17, 1996

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Event on November 17, 1996 has been studied by using a 3-dimensional global magnetohydrodynamic (MHD) simulation of interaction between the solar wind and the earth's magnetosphere when the WIND data in the upstream was used as input of simulation. A characteristic feature of the event was that z-component of the IMF (Interplanetary magnetic field) was changing its sign several times for somewhat short time intervals of $10 - 50$ minutes. The absolute value was from 5 nT to 10 nT. Since negative B_z component has a closed relationship to occurrence of tail reconnection, it is interesting to study the event by the MHD simulation. The solar wind velocity was about 500 km/s and the ion density was about 10/cc. In the simulation model the MHD and Maxwell's equations were solved as an initial value problem due to the modified leap-frog method. Number of grid points is $(n_x, n_y, n_z) = (500, 100, 200)$ and grid spacing is uniform of 0.5 R_E in three directions. The practical input data of WIND satellite is the solar wind number density, x-component of velocity, plasma pressure and IMF y- and z-components in the GSM coordinates. The electric conductivity in the ionosphere is Pedersen only and uniform by a value of 7 S. Thus these differences should be taken into account to compare the MHD simulation results with observations. We presented several kind graphics output of cross sectional profiles of energy in the noon-midnight and equatorial planes, polar plots of ionospheric convection and configuration of magnetic field lines every 10 minutes and every 1 minute. They are shown by movie. We analyzed simulation data and compared with SuperDARN observations.

S6-01

DYNAMICS OF GLOBAL AND LOCAL AURORAL FEATURES IN RELATION TO ENERGY COUPLING FROM THE SOLAR WIND AND THE MAGNETOTAIL

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Global imaging of the auroral region provides a means of studying the dynamics of solar wind - magnetosphere - ionosphere coupling at relatively high time and spatial resolution. The far-ultraviolet imager (UVI) on the Polar spacecraft was specifically designed to provide quantitative information on the energy flux and characteristic energy of the precipitating electrons as well as high-time resolution morphological changes over the northern hemisphere for up to 9 hours. Hall and Pedersen conductivities can be also be derived from these observations which provide a valuable input to Assimilative Mapping of Ionospheric Electrodynamic (AMIE) procedure. Use of precipitating electron energetics in auroral electrodynamics modeling and in comparison with MHD models has provided new insights into high-latitude ionospheric dynamics. Recent studies have also shown that some features of auroral dynamics do not always behave as predicted by current modeling techniques. For example, during relatively quiet times the auroral boundaries are similar to those inferred from MHD modeling but large discrepancies occur on the nightside during substorm expansions where the models fail to predict the extent of poleward expansion. A qualitative difference in auroral precipitation between storms and substorms has been discovered such that, during storms, the characteristic energy of the precipitating electrons is lower but the entire polar cap region can be filled with energetic ($\sim$1 keV) precipitation. We present examples of new insights which have come from the use of UVI data in modeling efforts and discuss some data analysis issues that are relevant to this endeavor including where models do not agree with the observations.

S6-02

MODELING AURORAL PRECIPITATION DURING SUBSTORMS USING GLOBAL MAGNETOHYDRODYNAMIC SIMULATIONS

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The ISTP spacecraft provide us with simultaneous observations of the upstream solar wind, the magnetosphere, and the aurora. We have used data from an upstream solar wind monitor to drive three dimensional global magnetohydrodynamic (MHD) simulations of the Earth's magnetosphere and a coupled ionospheric model. We have performed MHD simulations for several substorm intervals and have observed the evolution of the magnetospheric system. The auroral precipitation was modeled by assuming the precipitated energy flux into the ionosphere to be the analog of the observed auroral emissions. The MHD results were validated by comparison with observations within the magnetosphere by Geotail and the auroral model was compared with Polar VIS observations. In general the agreement was good and our results successfully reproduced auroral brightenings. Our main focus will be on our proven ability to map changes in the aurora to events in the magnetotail and to examine substorm dynamics.

S6-03

CUSP IONOSPHERE: EISCAT SVALBARD RADAR OBSERVATIONS AND TRANSCAR SIMULATIONS

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We report simulations of the high latitude cusp ionosphere using the TRANSCAR model and the comparison of this modelling to the Eiscat Svalbard Radar (ESR) measurements. Since the Z-component of the Interplanetary Magnetic Field (IMF) has to be strongly negative for the cusp to be observed at ESR, we implicitly model southward IMF cusp, and therefore, solar wind particle precipitation due to subsolar magnetopause reconnections. We will show how a given flux tube reacts while it crosses the cusp region and how the plasma parameters evolve with time inside the flux tube. We will see that due to large characteristic time in F-region, the electron density is not a reliable signature of the cusp. Besides, the electron density, measured by ESR , exhibits structures in the low F-region. We will discuss the possible mechanisms which could explain such structures. The high electron temperature in the cusp is usually attributed to precipitations of low energy electrons from the solar-wind. According to our modelling, this source of heating is not sufficient to reach the temperatures measured by ESR, especially in the low F-region. Therefore, an additional source of heating must be taken into account in order to fit the temperature profiles given by ESR.

S6-04

A PARTICLE-DRIFT MODEL OF THE QUIET-TIME INNER PLASMA SHEET WITH APPROXIMATE MAGNETIC FIELD SELF-CONSISTENCY

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The near-earth portion of the plasma sheet plays a significant role in transferring energy from the solar wind to the ionosphere through processes which involve strong coupling between plasma dynamics and the electric and magnetic fields. Here, we describe a new model of plasma sheet transport and structure and apply it to the quiet-time plasma sheet. Plasma transport in the model is calculated from a modified version of the Magnetospheric Specification Model, which simulates the bounce-averaged electric and magnetic drift of isotropic plasmas in an electric field and a magnetic field generated from the Tsyganenko 96 (T96) magnetic field model. An observation-based proton source is assigned to the tail and low-latitude boundary layer sources, and proton distributions and flow within the inner plasma sheet are obtained by collecting particles drifting from their tail sources under an approximately self-consistent magnetic field. Approximate self-consistency is obtained from the T96 model by the addition of small-scale adjustable ring-current shaped current loops. In these quiet time simulations, the electric field is assumed to be weak and time independent. We compare are model results to quiet time observations and find quite good agreement with observed pressures, densities, and flows throughout the equatorial plane. The relative contributions of the LLBL and tail plasma sources, the effects of maintaining a self-consistent magnetic field, and the relative contributions of electric versus magnetic drift are evaluated. We specifically find that the assumption $\boldsymbol{E} = -\boldsymbol{V} \times \boldsymbol{B}$ is not valid throughout most of the equatorial plasma sheet earthward of $r \sim 20R_E$.

S6-05

ENERGY COUPLING BETWEEN THE SOLAR WIND AND THE UPPER ATMOSPHERE ON A RANGE OF TIMESCALES

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We demonstrate that the coupling function of Stamper et al, which showed an unprecedently high correlation coefficient of 0.97 between the solar wind energy coupling function and the aa index using annual means, may be extended to other geophysical indices. This work also extends the analysis of the coupling function to timescales down to 1 day and demonstrates that the correlation with indices remains better than that produced by other published coupling functions. Methods of improving the correlation at times below 1 year, such as removing conductivity effects, are also discussed.

S6-06

THE IONOSPHERIC CLOSURE OF AURORAL CURRENTS

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Simultaneous observations of the FAST spacecraft orbiting over the EISCAT incoherent scatter radar facility will be used to study the characteristics of ionospheric current closure of upward field-aligned current within an auroral arc. The current closure is found to be provided by a strong perpendicular electric field region just adjacent to the auroral arc, in a region of very low conductivity. FAST observations confirm the strong electric field even at higher altitudes, in a region of intense and narrow downward field-aligned current carried by upward accelerated ionospheric electrons.

S6-07

OBSERVED AND SIMULATED NORTHERN POLAR CUSP POSITION AS FUNCTION OF INTERPLANETARY MAGNETIC FIELD

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The polar cusps are two narrow regions in the Earth's dayside magnetosphere, where the solar wind particles have direct access to the Earth's atmosphere. The cusps are spatially limited, and are usually observed near local noon at the (invariant) latitude of 80 degrees. The location of the cusp can rapidly vary by several hours in local time or several degrees in latitude if conditions in the solar wind and in the interplanetary magnetic field (IMF) change. In the large scale, the IMF north-south component controls the latitudinal location of the cusps, whereas the IMF east-west component controls the longitudinal location of the cusps. We present statistical analysis about the latitudinal location of the northern polar cusp, as measured by the Electric Field Instrument (EFI) onboard the NASA's Polar satellite. Observations show that the cusp tends to move southward with increasing southward IMF, whereas during northward IMF the cusp location is quite immune to the IMF variations. We compare the observed cusp position with the one obtained by an MHD simulation code (GUMICS-4) during various solar wind conditions. GUMICS-4 is a global magnetospheric simulation code with adaptive grid.

S6-08

PARTICLE SIMULATION OF THE MESO-SCALE STRUCTURE OF THE RING CURRENT

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A particle simulation code using bounce-averaged drift trajectories is used to study meso-scale structure in the ring current region. In particular we try to simulate the wedge-like dispersions observed by the Viking satellite. These structures consists of locally mirroring particles with energies less than some keV. They were commonly observed by Viking in the dayside magnetosphere at invariant latitudes between 55 and 70. The simulations indicate that the dispersion events can be modelled by assuming suitable boundary conditions which will be discussed in the talk. Furthermore the model has been used to study ring current proton precipitation when the particles are subject to pitch-angle diffusion with a strong diffusion life time (*i.e.* the loss-cone is filled within one bounce period). This is compared to DMSP measurements on a statistical basis and combined EISCAT incoherent scatter radar and DMSP measurements on a case study basis.

S6-09

MAGNETOSPHERE-IONOSPHERE COUPLING: GLOBAL MHD MODELS

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Global computer simulations have become an important means to study the solar wind-magnetosphere-ionosphere interaction. Most of global simulation models solve ideal magnetohydrodynamics (MHD) equations in the solar wind, magnetosheath and magnetosphere. The discretization process employed in numerical calculations introduces numerical dissipation which mimic physical dissipation processes, such as resistivity, diffusion and viscosity. The finite dissipation allows some critical processes, such as reconnection, to occur. In most models, the ionospheric coupling is modeled as the inner boundary conditions. In these models the ionosphere is considered as a height-integrated thin layer in which Ohm's law is approximated to relate the ionospheric electrical quantities. Various empirical relations are used to modulate the ionospheric conductances. We will review the success and limitation of such a description of the magnetosphere-ionosphere coupling.

S6-10

MHD SIMULATION OF THE SOLAR WIND-MAGNETOSPHERE INTERACTION AND RELATIONSHIP WITH POLAR PHENOMENA

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Configuration and dynamics of the earth's magnetosphere are strongly affected by variations of the solar wind and interplanetary magnetic field (IMF) for recent several hours. Directly driven process on the magnetosphere like a polar electric potential responds in about 10 minutes to their variations, on the other hand loading-unloading precess like onset of tail reconnection in the plasma sheet usually needs about 1 hour time delay from sudden southward turn of IMF. Therefore, it is necessary to know the present magnetospheric configuration as well as the present parameters of the solar wind and IMF in order to obtain future magnetospheric configuration. Magnetosphere and ionosphere coupling is one of important processes. In order to include the ionospheric feedback process to the global MHD simulation of the solar wind-magnetosphere interaction, field aligned currents are traditionally mapped from the inner boundary of magnetosphere onto the ionosphere, electric potential is calculated in the polar ionosphere by including ionospheric conductivity, and then convective electric fields are reversely mapped to the inner magnetosphere. We have tried the opposite procedure in our global MHD simulation. A 3-dimensional global MHD simulation of the interaction between the solar wind and the earth's magnetosphere has been executed to study the event of November 17, 1996 and the space weather "electrojet challenge" event of March 19 – 20, 1999. As input for the simulation, one minute values of solar wind parameters from the WIND and ACE satellites were utilized, namely the x-component of the solar wind velocity, the solar wind density, the plasma pressure and the y- and z-components of the IMF in solar-magnetospheric coordinates. We presented several kind of graphics outputs of cross sectional profiles of energy in the noon-midnight and equatorial planes, polar plots of ionospheric potential and configuration of magnetic field lines every 10 minutes.

S6-11

GLOBAL MODELING OF EARTH'S GEOSPACE ENVIRONMENT AND DATA COMPARISONS

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The effects of the solar solar wind and IMF reach through the magnetosphere into the ionosphere and thermosphere. In order to model this complex and intricate interaction we have coupled the UCLA magnetosphere-ionosphere model with the NOAA CTIM (Coupled Thermosphere Ionosphere Model). In coupling these models, CTIM receives the ionospheric potential and electron precipitation parameters from the MHD model and returns the conductances (Pedersen and Hall) and the ionosphere dynamo current to CTIM. We have compared model results for the January 10/11, 1997 storm event using different approaches for the ionospheric conductances (constant, parameterized, and from CTIM). We find that the coupled model comes closest to the observations. We also investigated the effect of the ionospheric dynamo currents and found that they have a negligible effect during the storm main phase, but may be of importance during the storm recovery.

S6-12

FAST FLOWS IN MHD SIMULATIONS OF MAGNETOTAIL DISRUPTION

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Fast plasma flows in the magnetotail are a major means of transport of plasma, energy, and magnetic flux. They also appear essential in the generation or enhancement of field-aligned currents providing the coupling with the ionosphere. Using results form large-scale MHD simulations, we discuss the temporal and spatial variations of fast flows, generated by magnetic reconnection, and the properties of the tail that might affect these variations.

S6-13

CAN NEAR-EARTH REGION AURORAL PLASMA PHYSICS BE INCORPORATED IN LARGE-SCALE MHD MODELS?

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Global magnetohydrodynamic (MHD) simulations typically contain an ionospheric module, which is coupled to the magnetospheric MHD equations through field-aligned currents (FACs) and the plasma convection pattern (electric potential). Sometimes one also models a field-aligned potential drop, which depends on the FAC and the local magnetospheric plasma density and temperature in some specific manner. Also the ionospheric conductivity enhancement due to magnetospheric electron precipitation is usually included in the simulations.

As our knowledge of the acceleration region and the so-called current-voltage relationship has recently advanced quite a bit, it is time to check and perhaps update also the ways in which the the ionosphere-magnetosphere coupling is implemented in global MHD simulations. In particular, there are now strong indications that although parallel electric fields are common on auroral field lines, net potential drops between magnetosphere and ionosphere need not be that common, except possibly during substorms. Also, the role of the FAC as a parameter governing the coupling, while still important, does not seem to be as crucial as previously thought. A major remaining problem is that the intensity of electron precipitation is still not possible to calculate self-consistently, but one has to rely on models which are calibrated using ionospheric measurements. We also discuss possibilities how to include the ionosphere as a plasma source, as well as the possibility of replacing the MHD equations by the quasineutral hybrid simulation model in the near-Earth region to better model the inherently multi-temperature nature of the plasma there.

S6-14

ON THE EQUIVALENCE BETWEEN ELECTROMAGNETIC AND MECHANICAL LOADS IN THE MAGNETOSPHERE-IONOSPHERE SYSTEM

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The generalized Ohm's law of magnetohydrodynamics, when applied to the ionosphere, is equivalent to the statement that the magnetic field is frozen to the electron fluid, rather than the ion fluid. This "freezing-in" of the electron fluid breaks down at very low altitudes, but generally applies throughout the E and F region ionosphere. An immediate consequence of the frozen-in condition for the electron fluid is the equivalence between electromagnetic and mechanical loads. (Here we assume that a mechanical load is one where the magnetic field does work on the plasma.) Since plasma flows are usually much larger than neutral winds within the ionosphere, it can be concluded that the ionosphere is both a mechanical and electromagnetic load on the magnetosphere. Poynting's theorem states that there is a net Poynting flux into an electromagnetic load in steady state and downward Poynting flux is taken to be an indicator of energy flow from a generator within the magnetosphere to the ionospheric load. As a corollary it might also be thought that upward Poynting flux means that the ionosphere is a generator of electromagnetic energy, but it must be remembered that it is the divergence of the Poynting flux that marks a generator or a load. In the absence of a neutral-wind dynamo, upward Poynting flux requires a convergence in the horizontal flux of magnetic energy, which contradicts the assumption of an incompressible ionosphere.

S6-P01

ELECTRIC CURRENT DENSITY DISTRIBUTION IN THE GEOMAGNETIC TAIL BASED ON GEOTAIL DATA

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Analysis of Geotail magnetic data enables us to reveal the antisunward electric current flowing along the tail axis. To our knowledge, observation of this current has not been reported yet. Distributions of the magnetic field and electric current density (along with their dependencies on the tilt angle of the Earth' dipole and components of the interplanetary magnetic field) have been derived directly from Geotail data, without any ad hoc assumptions. Analysis of the electric current density distribution shows that, in addition to currents associated with the geomagnetic tail flaring, there is a current (tentatively identified as the Hall current) flowing antisunward along the tail axis. The total strength of this current is of the order of 1 MA. It closes through the midnight sector of the auroral zone resulting in field aligned currents in the region of the Harang discontinuity.

S6-P02

STREAM FUNCTION METHOD FOR RECONSTRUCTION OF IONOSPHERIC CONVECTION PATTERNS

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The stream function method to restore the instantaneous convection pattern in the Earth's polar ionosphere is suggested. Plasma convection in the polar cap ionosphere is described as a hydrodynamic incompressible flow. This description is valid in the region where the electric currents are field aligned (and hence, the Lorentz body force vanishes). The problem becomes two-dimensional, and may be described by means of stream function. The flow pattern may be found as a solution of the boundary value problem for stream function. Boundary conditions should be provided by measurements of the electric field or plasma velocity vectors along the satellite orbits. It is shown that the convection pattern may be restored with a reasonable accuracy by means of this method, by using only the minimum number of satellite crossings of the polar cap. The method enables us to obtain the convection pattern without any preliminary information on ionospheric conductivities.

S6-P03

LONG-TERM, GLOBAL OBSERVATIONS OF SUPRATHERMAL ION OUTFLOW

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The ionosphere and magnetosphere are coupled by several processes with significantly different temporal and spatial scales. These processes involve large scale field aligned currents, plasma waves, precipitating energetic particles, and ionospheric plasma outflow. In terms of energy exchanged, ion outflow is the weakest of these processes. However, because of the significant time required for ionospheric ions to reach and affect the plasma sheet, there is a possibility of long term feedback effects. It has been difficult to explore the nature of feedback mechanisms because of the limited information available about the spatial and temporal coherence and variability of plasma escape from the ionosphere. Recent reports of the seasonal modulation in the strength of upflowing auroral ion beams in the evening sector demonstrate the importance of quantifying seasonal variations of other parameters that might possibly affect the strength of the magnetosphere-ionosphere interaction. We present data and empirical models derived from long-term, global, observations from the POLAR and Dynamics Explorer -1 satellites. We present methods by which these data might be incorporated into large scale magnetospheric models.

S6-P04

SYNERGETIC EFFECTS OF CURRENT DISRUPTION AND FLOW BRAKING FOR SUBSTORM ONSET WITH A SOUTHWARD IMF

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We have investigated the spatial and temporal development of Bursty Bulk Flows (BBFs) created by the reconnection as well as current disruptions (CDs) in the near-Earth tail using our 3-D global EM particle simulation with a southward turning IMF in the context of the substorm onset. Recently, observations show that BBFs are often accompanied by current disruptions for triggering substorms. We have examined the dynamics of BBFs and CDs in order to understand the timing and triggering mechanism of substorms. As the solar wind with the southward IMF advances over the Earth, the near-Earth tail thins and the sheet current intensifies. Before the peak of the current density becomes maximum, the reconnection takes place, which ejects particles from the reconnection region. Because of the earthward flows the peak of the current density moves toward the Earth. The characteristics of the earthward flows depend on the ions and electrons. Electrons flow back into the inflow region (the center of reconnection region), which provides current closure. Therefore the structure of electron flows near the reconnection region is rather complicated. In contrast, the ion earthward flows are generated far from the reconnection region due to the large gyroradius. These earthward flows pile up near the Earth. The ions mainly drift toward the duskside. The electrons are diverted toward the duskside. Due to the pile-up, dawnward current is generated near the Earth. This dawnward current dissipates rapidly with the sheet current because of the opposite current direction, which coincides with the dipolarization in the near-Earth tail. At this time the wedge current may be created in our simulation model. This simulation study shows the sequence of the substorm dynamics in the near-Earth tail, which is similar to the features obtained by the multisatellite observations. The identification of the timing and mechanism of triggering substorm onset requires further studies in conjunction with observations.

S6-P05

VARIATION OF POLAR CAP DENSITY

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We investigate the plasma density variation in the polar cap region as a function of altitude, season, and geomagnetic activity, using Polar EFI observations from April 1996 to December 1999. The polar cap density varies strongly with season. For instance, at low altitudes ($siml\ R_E$), the density is an order of magnitude higher in summer than in winter; in the high altitudes ($>4\ R_E$), the amplitude of this variation is somewhat smaller. Along a magnetic field line the density declines between these two altitudes by a factor of $10-20$ in winter and by a factor of $200-1000$ in summer. The geomagnetic effects are also clearly observed in the polar cap density so that the average density is an order of magnitude higher for high Kp than for low Kp, which suggests that for an individual storm, the polar cap density may increase even more dramatically. We compare these observations with the densities predicted by polar wind models.

S6-P06

ON PROBLEM OF ENERGY TRANSFER FROM THE SOLAR WIND INTO THE OPEN MAGNETOSPHERE

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The problem of energy transfer from the solar wind into the magnetosphere is discussed. A revaluation of the known notions about an open tail magnetopause as a boundary containing a rotational discontinuity is done. It is shown that the formulae proposed by various authors to describe the Poynting vector flux into the magnetosphere are often in rather poor agreement with each other. It leads to confusion in the issue of the energy transfer and to the erroneous versions of a substorm scenario. Nevertheless, one can decide between the different notions about an energy transfer those better fitting into the modern concepts founded on space and ground-based observations. This study is supported by the Russian Foundation for Basic Research (grant 98-05-65120).

S6-P07

ELECTRON DENSITY RESULTS FROM A GLOBAL PLASMASPHERE MODEL – COMPARISONS TO LOW EARTH ORBIT SATELLITE OBSERVATIONS

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The plasmasphere is a body of cold dense plasma located above the ionosphere, which extends out to a distance of three to six Earth radii. A large data base on these ionized regions comes from studying their effects on radio signals transmitted from satellites in the Global Positioning System (GPS) constellation, orbiting at an altitude of 20,200 km. The increasing use of GPS radio signals to study the ionosphere has necessitated the development of a method to estimate the plasmaspheric contribution, so that it can be separated or removed. To estimate the plasmaspheric contribution, the Global Plasmaspheric Ionospheric Density (GPID) model has been developed. GPID is a global dynamic model that runs on a desktop PC. It is designed to calculate the electron density quickly and accurately, up to an altitude of 30,000 km. The model is based on diffusive equilibrium, with chemical equilibrium included at low altitudes when appropriate. The model includes hydrogen ion production and loss, refilling of magnetic field lines, effects of magnetic storms, and cross L-shell drift. Direct plasmaspheric TEC measurements obtained from GPS receivers on board Low Earth Orbit (LEO) satellites, including the recently launched Danish Ørsted microsatellite, will be shown. Results from the Field Line Interhemispheric Plasma (FLIP) model and the Sheffield University plasmasphere ionosphere model (SUPIM), two more physically complete plasmasphere models, will be compared to the simpler GPID model.

S6-P08

MSM TRACING OF MAGNETOSHERIC PARTICLES USING THE KRM-DERIVED ELECTRIC FIELDS

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The primary purpose of this simulation study is to trace particles in the magnetosphere using the MSM code. For this purpose, we use the electric fields which are derived from the KRM algorithm and from existing empirical models, such as the Heppner-Maynard model. In the simulation, we calculate differential energy fluxes of the partilces and the current intensity at each grid point on the equatorial plane of the magnetosphere. (1) The results of the simulation from the KRM electric fields show that locally enhanced electric fields on the night side at the expansive phase of substorms appear to transport particles efficiently to the inner magnetosphere. Substorm-time variations in the calculated particle fluxes seem to be more realistic than those resulting from the empirical models, indicating the importance of local enhancements in the electric fields seen in the KRM fields. (2) By integrating the azimuthal component of currents using Biot-Savart's law, we calculate the magnetic field perturbations at the Earth, which is the expected *Dst* index. A reasonable agreement is obtained between the calculated and observed *Dst* values. (3) We also attempt to reproduce various patterns in energy-time spectrograms, *i.e.*, single- and multiple-band structures, obtained by spacecraft observations in the near-Earth magnetosphere. We will discuss how changes in spatial/temporal structures in the model electric fields relate to the formation of these patterns.

S6-P09

THE MALIN-ISIKARA EFFECT: SEMIANNUAL VARIATION OF THE GEOMAGNETIC *Dst* INDEX

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The geomagnetic *Dst* index exhibits a strong semiannual variation with an amplitude of 5.0 nT (on a baseline of 16.3 nT) for the years 1957 – 1991. If we remove all storms with peak $Dst < -30$ nT from the *Dst* time series for this period, the amplitude of the variation only decreases to 3.8 nT, indicating that $\sim$ 75% of the seasonal variation of averages of this index results from modulation of the remaining "baseline". The Malin-Isikara effect – the seasonal deformation of the magnetosphere by solar wind compression – is a good candidate to account for the strong underlying modulation that persists after storm removal. According to this hypothesis, most of the six-month wave in average *Dst* results from seasonal motion of the ring and tail currents relative to the observing stations in the *Dst* magnetometer network. The three classical hypotheses (axial, equinoctial, and Russell-McPherron) that work by modulating the intensity of the ring current appear to contribute only $\sim$ 25% to the seasonal variation of *Dst*. Of these three, the equinoctial effect is the most important.

S6-P10

DOES THE APPEARANCE OF HIGH-LATITUDE SUBSTORMS DEPEND ON SOLAR WIND THERMAL PRESSURE?

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It is known that substorms propagating from auroral zone to very high latitudes (high-latitude substorms) occur mainly during high-speed solar wind (SW) conditions. The reason for such dependence is still not clear. We tried to find a "physical" parameter which may correlate with solar wind velocity and which may affect on distant magnetotail where the high-latitude substorm originate from. We found that, indeed, there is another parameter - solar wind thermal pressure - which also correlates with the substorms. This parameter is the main factor responsible for magnetic pressure in the distant tail lobes. This means that the increased SW thermal pressure should correlate with the plasma sheet current intensity in the far tail. This might be a reason for the substorm development here. To check this idea we investigated some 20 events of extremely high SW thermal pressure (up to order higher than typical value) occurred at fronts of the high-speed solar wind flows. During the events the GEOTAIL satellite was at distances $50-200\ R_E$ downtail, and it measured very high values of the magnetic field in the tail lobes. However only few high-latitude substorms were registered during these cases. The substorm occurrence strongly increased in $1-3$ days after the events, when the magnetosphere was inside the high-speed SW flow and the thermal pressure dropped. Thus, we conclude that SW thermal pressure is, probably, not the crucial factor determining the development of high-latitude substorms. It is essential to find another mechanism of solar wind control on substorms in which SW velocity plays the crucial role.

S6-P11

ANTI-SUNWARD CURRENT SYSTEM OBSERVED BY THE ØRSTED SATELLITE

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The Ørsted satellite was launched on February 23 1999, and flew near noon–midnight meridian for the period between August and October. During the period, following characteristics at mid and low latitudes are found: (1) An effect of the ring current can be seen in radial component and north–south component. Perturbations caused by Sq currents is seen in the dayside radial component. The equatorial electrojet is observed in the dayside north–south component. An effect from ionospheric current system around the noon is observed in the dayside east–west component. (2) East–west component (eastward positive) shows distinct variations. It has positive value in the southern hemisphere and negative value in the northern hemisphere on the dayside, and opposite on the nightside. The tendency is more prominent when the orbit plane is in near noon–midnight meridian, and in geomagnetically disturbed period. This indicates the existence of the field-aligned currents flowing into the earth's ionosphere around the noon, and flowing out around the midnight. This current is considered to connect with anti-sunward current system. We compare this observation with a field-aligned current model which interprets this observation.

S6-P12

MHD MODELING OF THE SOLAR WIND DISTURBANCES-EARTH MAGNETOSPHERE INTERACTION

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The special computer program allowing to carry out two dimention MHD modeling of space - time dynamics of magnetized plasma flow with motionless area of strong magnetic fields is created. The computing modeling opportunity of interaction of variating plasma flow of solar wind with Earth's magnetosphere is shown. Base model of the solar wind was magnetized homogeneous plasma, which movement velocity exceeds the velocities of all normal linear waves. The modeling of structure, such as bow shock wave and a magnetosphere cavity, arising at collision of space plasma flowing into dipol geomagnetic field was executed. Non-stationary transitional processes, caused by inhomogeneities of density and solar wind flow velocities, and also by values and orientation of the interplanetary magnetic field are analysed by means of constracted computing programm. It is established, that thin features of dynamic influence of Solar wind on terrestrial magnetosphere can not be revealed only by analysing of disbalance of solar wind dynamic pressure and geomagnetic field. Even if the contribution of magnetic field to pressure of solar wind is insignificant, inhomogeneity of solar wind, containing IMF of "southern" directions, cooperates with terrestrial magnetosphere qualitatively different from inhomogeneity of "northern" direction. The distinctions of qusistationary picture of undersolar magnetosphere are investigated for cases of cross IMF of northern and southern directions. The attention is paid to reduction of model undersolar magnetosphere sizes in presence of IMF of a southern direction. The special efficiency of influence of longitudinal solar wind velocity inhomogeneity on magnetosphere, resulting in significant impulse of geomagnetic field. The results, obtained during computing experiment, can to be used for the explanation of connection between space medium parameters and given measuring of geomagnetic field.

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S6-P13

ON UNUSUAL MAGNETIC FIELD ON GEOSTATIONARY ORBIT IN LOCAL MIDNIGHT

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It is known, that geomagnetic field is increased in compare with dipole field in day side, and decreased in night side for interaction with solar wind. Analysis of GOES-5 and GOES-6 magnetic data from 1986 to 1994y shows, that magnetic field can reach dipolar value near local midnight during equinox time intervals (1 – 1.5 months). This phenomena is observed independently from geographical longitude Increasing of magnetic field in local midnight was not observed in other time intervals during every year. Analyse of such increasing of magnetic field and the structure of field align current system shows that low latitude flowing to ionosphere current is begining in evening side of a border of GOES magnetic field increasing. We propose that if $+B_z$ of IMF exists long time interval, dipolisation of magnetic field develops in more high latitude magnetic lines and we observe Theta-aurora. Dipolisation of magnetic field was observed by satellites GOES-5 and GOES-6 near local midnight near equinox and was not observed by GOES-7. We propose, that GOES-5 and GOES-6 were near geomagnetic equator in longitudes $75 - 120$ W, GOES-7 was in geomagnetic latitde $\sim$10 degree in that longitudes. Near solsice intervals magnetic lines were disturbanced and position of effective geomagnetic equator shifts along latitudes.

S6-P14

PROPERTIES OF THE PLASMA SHEET AND THEIR CONNECTION WITH MAGNETOSPHERIC PLASMA TRANSPORT

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It is widely accepted that magnetic reconnection at dayside magnetopause plays a key role in plasma dynamics in the Earth's magnetosphere when the IMF is southward. This natural view, however, may not be necessarily applicable to the cases with the northward IMF. From Geotail observations we show that in the near-earth plasma sheet cold dense plasmas (CDP) are found principally when the IMF is northward, and that the plasma "vertical content", namely the product $N_p \times L$ with the plasma density N_p at the plasma sheet center and the characteristic thickness L, often shows significant increases during the northward IMF. We will discuss possible physical interpretations of these observations.

S6-P15

COORDINATED STUDY ON THE ELECTRODYNAMICS AROUND THE MOST POLEWARD ARC SYSTEM OF THE DOUBLE OVAL CONFIGURATION IN A SUBSTORM WITH EISCAT, SATELLITES, AND GROUND-BASED OBSERVATIONS

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A campaign observation of the nightside high latitude aurora was carried out at Longyearbyen (LYR), Svalbard in March, 1999. A good auroral activity was observed on 10 March. During that time, very fortunately, EISCAT Svalbard Radar (ESR) was operating and the footprints of the FAST and GEOTAIL satellites passed within the FOV of LYR. POLAR UVI images showed that an auroral brightening occurred over the IMAGE stations, bulge expanded poleward, its poleward edge reached Svalbard, and then so-called double oval configuration appeared. Main results are as follows;

1. It was clearly shown that the most poleward arc was associated with the phenomena around the PSBL region. The VDIS ions and downward field-aligned current (FAC) were situated at the higher latitude side of the arc, and upward FAC situated around the arc. Within the PSBL region, both ion and electron heatings were observed with ESR, and soft electron precipitation was with the Meridian Scanning Photometer (MSP). In the recovery phase, the most poleward arc moved equatorward with a higher velocity than the heating and soft electron precipitation region. As a result, latitudinal width of the PSBL region became wider as time progressed.

2. Comparing with the low and high altitudes observations, spatial relationship among the FACs, VDIS ions, and the electric field is qualitatively consistent with each other, except EY component. As for the VDIS ions, a clear velocity dispersion could be seen at GEOTAIL, while only higher energy part was observed by FAST. The lower energy ions should enter the plasma sheet during their flights and appeared at the lower latitudes after being accelerated. EY component at the low altitude should be mainly static, while at the high altitude, inductive one due to the plasma sheet expanding motion should be dominant.

S6-P16

A SURVEY OF ION DISTRIBUTIONS FOUND IN THE MID TO DISTANT PLASMA SHEET

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In this study, we use Geotail observations to identify a number of mid to distant tail rapid plasma sheet crossings in which the spacecraft crosses from the north to the south lobe, or vice versa. In particular, we examine the evolution of the multi-component ion distributions obtained by the LEP instrument as the spacecraft crosses from the lobe regions into the plasma sheet boundary layer and the plasma sheet proper. We determine the properties of the ion distributions observed during both reconnection and non-reconnection type plasma sheet encounters. Using this data set we determine the role each of the plasma populations plays in maintaining stress balance across the central tail region. The speed of the crossings also allows a near instantaneous sampling of the north and south lobe regions directly adjoining the plasma sheet. We investigate the effects on plasma sheet structure when the neighbouring lobe regions have significantly different properties.

S6-P17

APPROXIMATION FOR THE MAGNETOSPHERIC MAGNETIC FIELD

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A magnetic field model is suggested for distances up to 40 Earth's radii. The model depends on the dipole tilt angle, Dst and Kp indices, solar wind dynamic pressure, and IMF vertical component. An advantage of this model over the Tsyganenko-96 model is much simpler field presentation as well as smaller residual error.

S7-01

FAST MAGNETOSPHERIC CONVECTION AND ITS IONOSPHERIC COUPLING

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The rapid increase of magnetic flux in the near-Earth region of the magnetosphere during the expansion phase of a substorm requires magnetic flux to be brought in from the magnetotail, which presupposes fast magnetospheric flow. A stress imbalance is needed to create such a fast flow, and several possible mechanisms for it will be discussed. Because the magnetic field is changing, coupling to the ionosphere cannot be determined by simple mapping but requires describing transport of stress and current by Alfvén waves.

S7-02

DO THE OBSERVATIONS CONFIRM THE HIGH-SPEED FLOW BRAKING MODEL FOR SUBSTORMS?

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We selected several cases when Geotail satellite situated in the mid-tail was in conjunction with ground-based all-sky TV cameras observing auroral breakups. Localization of auroral events within the field of view of ground-based stations has been controlled by the Polar imager data. Some of the events exhibited the existence of high-speed ($500-700$ km/s) Earthward plasma flows within the plasma sheet before the breakups. To verify if the fast flow could be a cause of the breakups a detailed consideration and timing of the phenomena has been done. We concluded that in the considered cases there was no causal relationship between fast Earthward flows and breakups. In addition a search for auroral precursors, which could appear poleward of pre-breakup arc just before breakup, has been performed. As such structures might be subvisual, some filtration methods were applied to the TV data. Our analysis did not show any auroral precursors. Thus, our observations failed to confirm the model of substorm, which connects the auroral onset with the braking of the high-speed Earthward plasma flow.

S7-03

INFLUENCE OF THE IONOSPHERE ON MAGNETOTAIL CONVECTION

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The magnetotail is coupled to the ionosphere along auroral field lines by means of field-aligned currents and Alfvén waves. The ionosphere influences magnetotail convection by producing a frictional drag. This drag manifests itself by the $\boldsymbol{J} \times \boldsymbol{B}$ force associated with the magnetospheric current that closes the auroral field-aligned current system. Thus, this drag can be affected by changes in this current system. In particular, changes in the ionospheric conductivity or the development of parallel electric fields can affect the effective ionospheric drag. Enhancement of the conductivity increases this drag by increasing the total current in the system. In contrast, a parallel electric field causes a reduction in the current, and can decouple magnetospheric convection from the ionosphere. This decoupling occurs at scales below a critical scale length that depends on the effective current-voltage relation along auroral field lines and on the Alfvén conductivity in the acceleration region. The sudden development of a parallel electric field could produce a localized enhancement of tail convection, which could in turn affect convection patterns and pressure distributions in the tail. Consequences of this model for the onset of substorms will be considered.

S7-04

A QUANTITATIVE EXPRESSION OF THE ELECTRIC-FIELD PROPAGATION IN THE MAGNETOTAIL AND ITS APPLICATION TO THE CONJUNCTION STUDY BETWEEN AKEBONO AND GEOTAIL

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The response of the ionospheric convection to the electric field variations launched from the magnetotail is examined. We make a model calculation for an Alfvén wave traveling between the ionosphere and an arbitrary location in the magnetosphere. The result of the calculation suggests that short-period electric field variations in the magnetotail are filtered out at ionospheric altitude. On the other hand, long-period variations reach the low-altitude region without being diminished and excite a global and lasting convection in the ionosphere. The time delay of variations in the ionosphere behind those at the location in the tail increases with decreasing frequency.

We apply the result of the calculation to the experimental data obtained by Akebono and Geotail simultaneously. We find that the electric field data of two satellites are basically consistent with the model calculation. In order to match the observed satellite data with the calculation more precisely, however, the effective reflection ratio of Alfvén waves at the ionosphere requires to be higher than the realistic number estimated from the precipitating particles. Some possibilities to interpret higher effective reflection ratio are discussed.

S7-05

NON-MHD EFFECTS IN FIELD-ALIGNED CURRENT GENERATION BY RECONNECTION JET

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Recent Geotail spacecraft data analysis studies show that the current components generated by the Hall term in the course of magnetic reconnection in the magnetotail are indeed present and are of non-negligible intensity. Recent three-dimensional Hall-MHD simulations of reconnection have shown that the Hall term modifies the current system so significantly as to result in a totally different structure from MHD models. Since the ion finite-Larmor radius effects would be important as well, three-dimensional hybrid simulation is required to fully understand the current generation that results from field-line twisting by reconnection jet. Results of three-dimensional Hall-MHD simulations will be reviewed and results of three-dimensional hybrid simulations will be reported to show how these non-MHD effects modify (semi-) global aspects of the substrom current pattern.

S7-06

THE GENERATION AND CONSEQUENCES OF FIELD-ALIGNED CURRENTS FROM FAST FLOWS AS SEEN IN MHD SIMULATIONS

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Observations and simulations have demonstrated a strong association between fast flows in the magnetotail and auroral features associated with increased field-aligned currents. We discuss the mechanisms and properties of the connection between flows and field-aligned currents, based on MHD simulations.

S7-07

FLOW CHANNELS IN THE MAGNETOTAIL: TAIL AND IONOSPHERIC OBSERVATIONS COMPARED WITH GLOBAL MHD SIMULATIONS

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Analysis results are shown from an extended period of enhanced energy input from the solar wind into the magnetosphere. During this period, Dec 17, 1997, GEOTAIL in the midnight sector magnetotail recorded several intense flow bursts, which caused auroral and magnetic activity in the conjugate ionosphere recorded both by the POLAR imagers and the ground-based MIRACLE instrument network. Three such intense flow bursts caused only localized geomagnetic activity, while the fourth one was associated with global activation of the magnetosphere, a substorm onset. The Lyon-Fedder-Mobarry global MHD simulation is used to examine the formation, size, and nature of the flow bursts during the entire period. The flow channels in the simulation are shown to be equivalent to the bursty bulk flows that are frequently observed in the magnetotail during geomagnetically active periods. We compare and contrast the simulation and observational results to gain understanding of the factors controlling the size and evolution of the flow channels.

S7-08

ISTP OBSERVATIONS OF THE TEMPORAL AND SPATIAL EVOLUTION OF MAGNETOSPHERIC SUBSTORMS

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Examination of ISTP measurements taken by radially aligned spacecraft in the nightside magnetosphere during two substorms on July 9, 1997 has revealed close temporal correlations between the flow bursts in the central plasma sheet, dipolarization in the inner magnetosphere, auroral brightening/breakup and the ejection of plasmoids. Despite simplifying assumptions, the quantitative application of the NENL model neutral line to these observations indicates that lobe field line reconnection commenced at distances of $X \sim -17$ to $-18\ R_E$ several minutes prior to the observed "onset" of the substorm expansion phase in the auroral oval and the subsequent intensifications. For both substorms the initial magnetic dipolarization in the inner magnetosphere is first observed farther down the tail by Geotail and then later at GOES. However, the magnetic field reaches its final dipolarized state first at the inner spacecraft, GOES, and only later at Geotail in agreement with the magnetic flux "pile-up" scenario for dipolarization. In addition, the magnitude of the ram pressure measured in the flow bursts was found to be comparable to the plasma sheet thermal pressure increases that accompany dipolarization consistent with these flows "braking" as they snowplow into the

inner magnetosphere. In summary, the temporal and spatial of the evolution of the July 9, 1997 substorms are in excellent agreement with the overall predictions of the NENL model and, more specifically, the magnetic flux pile-up and flow braking concepts for substorm current wedge development.

S7-09

EVIDENCE IN IONOSPHERIC CONVECTION FOR MAGNETOSPHERIC ENERGY SURGES

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Magnetospheric reconnection has often been associated with regions of enhanced magnetospheric plasma transport perpendicular to the local magnetic field. The largest flow velocities are expected to occur in the vicinity of reconnection sites and the temporal variability of the flows are expected to mirror the reconnection rates. Because of the high electrical conductivity along magnetic field lines in the magnetosphere and topside ionosphere, the quasistatic component of magnetospheric electric fields should map along magnetic field lines into the high-latitude ionospheres where it can be measured with satellites, rockets, radars and balloons. There is substantial evidence that enhanced ionospheric convection occurs in association with increases in dayside reconnection. These flow enhancements are observed most strongly in the dayside ionosphere, but they are also seen at other local times including midnight. Ionospheric flow enhancements in association with nightside reconnection events have been much more difficult to identify. In this paper, we present examples of transient, localized enhancements in ionospheric convection and discuss them in terms of dayside and nightside reconnection enhancements. The most obvious characteristic of this study is that ionospheric convection generally responds in a globally coherent manner as might be expected from a potential field.

S7-10

DOUBLE AURORAL BAND FORMATION IN THE POLEWARD EXPANSION OBSERVED BY IMAGING RIOMETERS AT 75 – 77 INVARIANT LATITUDE

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The interhemispheric conjugacy of auroral poleward expansion was studied using conjugate imaging riometers at 75 – 77 inv. (Zhongshan Station, Antarctica; Longyearbyen, Svalbard; and Danmarkshavn, Eastern Greenland). Several case studies of poleward expansion at 75 – 77 inv. were performed including a small high-latitude magnetic disturbance centered at 75 inv., and a substorm starting at 71 inv. and expanding to 76 inv. The poleward expansion at this latitude was characterized by a stepwise progression of CNA bands to higher latitudes. In other words, a new CNA band was formed 50 – 180 km poleward of the preceding band. A close relationship was seen between the appearance of a new CNA band and the equatorward motion of the preceding ones.

The magnetospheric source of the equatorward moving CNA bands was considered as follows. Energetic electrons formed at the reconnection site are injected earthward by the reconnection electric field. This motion can be seen at the foot of the fieldline as the equatorward motion of the CNA band. The energetic electrons gain additional energy from Betatron and Fermi acceleration as the fieldline in which the electrons are trapped dipolarizes. Just after the reconnection, the small curvature of the reconnected fieldline at the tail causes pitch angle scattering of the trapped electrons. The electrons that fall into the loss cone are then precipitated into the polar ionosphere, where they form a CNA band. The precipitation continues until the curvature of the dipolarized fieldline becomes much larger than the Larmor radius of the trapped electrons, halting the process of pitch angle scattering. This process can explain persistence of the equatorward moving CNA band for several minutes.

S7-11

MAGNETOSPHERIC ENERGY SURGES AND THEIR IONOSPHERIC COUNTERPART: GEOTAIL-POLAR OBSERVATIONS

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The energy stored in the Earth's magnetotail is released in the form of explosive particle flow and heating. In association with this magnetospheric energy surge, ionospheric energy surge takes place in the form of aurora and ionospheric current. Multi-point studies using ISTP satellites combined with ground network enable us to investigate the temporal and spatial relationships between the magnetospheric energy surge and the auroral ionosphere.

In this paper, recent studies on the relationships between aurora and bursty bulk flows, which are considered to play a key role in the magnetospheric energy surges, will be presented based on Geotail, Polar, and ground-based observations. The topics include auroral evidence of field-aligned currents generated by localized bursty bulk flows; timing of the flow bursts and auroral development; spatial scale of the flow bursts inferred from the conjugate aurora. Energy surges for different state of the magnetosphere, *i.e.*, quiet time, pseudobreakups, substorms, convection bays, will be discussed.

S7-12

WIND AND GEOTAIL OBSERVATIONS OF HIGH SPEED FLOWS IN THE MID-TAIL AND NEAR-EARTH PLASMA SHEET AND THEIR IONOSPHERIC SIGNATURES

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We present simultaneous observations of plasma sheet dynamics in the mid-tail and near-Earth regions by the WIND and Geotail spacecraft. WIND (located at $X_{gse} \sim -60\ R_E$) observed high speed flows consistent with reconnection and the presence of a reconnection X-line in the mid-tail ($X_{gse} \sim -60\ R_E$) region. Geotail was located closer to the Earth, at $X_{gse} \sim -25\ R_E$, during these times but did not detect most of the high-speed convective flows seen at WIND except for short periods of bursty bulk flows. The only other high speed flows detected by Geotail were field-aligned ion beams confined to the lobe-plasma sheet boundary. The AE index was low during the 10 hours when WIND detected the mid-tail reconnection flows, but seems to be better correlated with periods of near-Earth bursty bulk flows detected by Geotail. We will discuss the relationship between mid-tail reconnection flows with near-Earth bursty bulk flows and their consequences on ionospheric activities.

S7-13

COMPREHENSIVE OBSERVATIONAL EVALUATION OF THE MAGNETOSPHERIC INSTABILITY ASSOCIATED WITH FAST FLOWS

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On the basis of wave and plasma observations of the Geotail satellite, the instability mode of low-frequency ($1 - 10$ Hz) turbulence associated with fast ion flows in the magnetotail has been examined. Wave spectra obtained by the the spherical double-probe instrument usually show the existence of electrostatic wave activity in the lower hybrid frequency range in the plasma sheet boundary layer during substorm. The linear and quasi-linear calculations of the lower hybrid drift instability/the modified two stream instability well explain the observed electrostatic turbulence quantitatively. The calculated characteristic electron heating time is comparable to the timescale of the expansion onset, and a statistical study of lower hybrid waves in the plasma sheet shows that wave activity is closely related to electron heating (ion-electron temperature ratio). These results imply that the lower hybrid waves observed in the plasma sheet boundary layer with fast ion flows are very much important for the electron heating in the magnetotail. We think that the free energy of lower hybrid waves is primarily a density gradient of fast ion flows at the plasma sheet boundary layer.

S7-14

SIMULTANEOUS MULTIPLE SATELLITE STUDIES OF FAST FLOWS AT ALTITUDES: THE INTERVAL PERSPECTIVE

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We present recent new observations of impulsive keV ion injections into the auroral oval. Using correlated Interball, Polar and ground measurements, sporadic and recurrent plasma sheet ion injections into the high altitude ionosphere are shown to be linked with substorm expansion phases. Time of flight dispersions after ion ejections from the tail mid-plane lead to the observed velocity dispersed signatures (TDIS). The ejection region can extend over a wide range of radial distances, from $7-40$ R_E in the nearly equatorial magnetosphere. Both hydrogen and oxygen ion are ejected toward the Earth's upper ionosphere. Sporadic TDIS are systematically measured near the poleward border of the northward expanding auroral bulge wich suggest that the same physical mechanism is at work throughout the mid-tail during substorm expansion phase. We show that ion injections are also detected well inside the bulge which suggest that injection fronts propagates from the outer to the inner magnetosphere over large distances. TDIS coincide with very large ionospheric ion outflows (both hydrogen and oxygen) in the $<$ 100 eV to the keV range which lead to conclude that substorm events play a major role in populating the plasma sheet with ionospheric ions. The correlation of TDIS with fast plasma flows detected in the tail onboard Geotail is experimentally demonstrated.

S7-15

THE AURORAL SIGNATURE OF MAGNETOTAIL FLOW BURSTS

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We present direct evidence that transient Earthward flow bursts in the magnetotail can produce an observable signature in the optical aurora. This signature is north-south aligned auroral structures that are extensions of transient intensifications near the poleward boundary of the auroral oval, referred to as poleward boundary intensifications (PBIs). Our initial case study focused on the period from 0500 to 0700 UT on January 7, 1997, during which five distinct flow bursts were observed in the Geotail data. At that time, the spacecraft was located approximately 30 R_E downtail on field lines that project down to the CANOPUS array of ground based instruments. Each of the flow bursts seen in the Geotail data was associated with a PBI observed in the CANOPUS meridian scanning photometer data, which appears as a north-south aligned auroral structure in the CANOPUS all-sky imager data. Further examples with full two-dimensional auroral coverage from the ground and with Geotail in the plasma sheet are being used to test the generality of the above results.

S7-16

A POSSIBLE FATE OF THE EARTHWARD ION FLOW INTO THE LOW-L REGION: PARTICLE SIMULATIONS AND VIKING OBSERVATIONS

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A part of the earthward ion flow is expected to inject into deep inner magnetosphere, but not much study are done in finding the corresponding plasma cloud or simulating its fate. Recently, a structured enhanced sub-keV ion "cloud" in the morning sector with wedge-like energy-latitude dispersions was found in the Viking data. This "deep plasma segment (DPS)" is also observed by Freja and Astrid-2. We found, by means of particle simulations, that DPS is well understood by nightside temporal plasma injection many hours ($5 - 15$ hours) before the observation. In the particle simulation, we traced bounce-averaged drift trajectories of ions under the dipole magnetic field and the Volland-Stern type convection electric field. This reproduced various dispersion patterns seen by Viking. Some of the Viking observation could correspond to continuous ion injection from narrow flow channels having characteristic width of 1 R_E in the near-earth tail, while some could correspond to pulsed injection which lasts 1 hour and more.

S7-P01

CHARACTERISTIC ENHANCEMENT OF LOBE ION DENSITY ASSOCIATED WITH THE PASSAGE OF A PLASMOID: 1. AN ANTI-SUNWARD MOVEMENT OF THE NENL AFTER PLASMOID EJECTION

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The GEOTAIL satellite has often detected a characteristic enhancement of ion density and velocity in the lobe of the distant magnetotail. It is observed $5 - 30$ miniutes after passage of a plasmoid. A bipolar signature in B_z is observed at the same time as the ion enhancement, and the B_z perturbation involves a change from negative value to positive value, which is opposite in polarity to that expected from a plasmoid or TCR.

In this study, we analyze this kind of events in detail. Based on the model of *Siscoe and Sanchez* [1987] explaining the relation between ion density and velocity in the lobe (mantle), we investigate the cause of the enhancements. It is concluded that this kind of ion enhancement is caused by a configuration change of the magnetotail associated with passage of a plasmoid. We also suggest that the configuration change may be due to an anti-sunward movement of the near-Earth neutral line (NENL) to become a distant-tail neutral line (DTNL), associated with plasmoid ejection.

Our study suggests that after formation the NENL follows the plasmoid as it moves downtail.

Reference

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S7-P02

CHARACTERISTIC ENHANCEMENT OF LOBE ION DENSITY ASSOCIATED WITH THE PASSAGE OF A PLASMOID: 2. DETAILED ANALYSIS OF THE EVENTS

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As will be reported in the accompanying paper in the meeting by *Takada et al.*, the GEOTAIL satellite has often observed enhancements of ion density and velocity in the tail lobe. In that paper, they concluded that these effects are caused by a configurational change of lobe field lines associated with an anti-sunward movement of a near-earth neutral line after a plasmoid ejection. In this paper, we attempt to verify their conclusions.

To begin with, we analyze lobe ion enhancements which accompany a bipolar signature in the magnetic field component B_z that is opposite in polarity to that expected from a plasmoid or TCR. In particular, the timing of the B_z variation compared to that of the ion density enhancement is examined and good agreement is found with the model that we suggested. The peak in the density enhancement corresponds to the time when $B_z = 0$. It will be shown that the average time between the passage of a plasmoid and the lobe ion density enhancement is 40 minutes, which is the expected time delay between the passage of the plasmoid and the passage of the near-earth neutral line in its wake.

We then analyze the ion density enhacements not accompanied by a bipolar signature in B_z. We find that many of these events were detected near the magnetopause, from which it is concluded that their source is different from the other events discussed earlier in the talk. We suggest that these events are due to tail flapping, waves originating from the Kelvin-Helmholtz instability or breathing of the magnetotail associated with substorms.

S7-P03

ION AND ELECTRON PARAMETERS IN THE DISTANT MAGNETOTAIL ON THE BASIS OF GEOTAIL OBSERVATIONS

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It is widely known that ion temperatures in the plasma sheet are several times higher than the electron temperatures. It has been found that the ion-to-electron temperature ratios (T_i/T_e) tend to increase with large tailward velocities in the distant tail, as a result of statistical analysis of ion and electron parameters obtained during neutral sheet crossings of the Geotail spacecraft. Investigating the variation of temperature ratios is meaningful to understand energy distribution dependent on the particle species. We have selected dozens of examples from the whole data obtained in the distant tail ($X < -50\ R_E$). The duration of each example is a few hours, and includes the data in the plasma sheet and the boundary layer, not only at the neutral sheet crossings. We exclude the data in the lobe. In many cases, the temperature ratios indicate high values as the plasma β increases. Its tendency is clear in the boundary layer whose plasma thermal pressure is equal or less than the magnetic pressure. It is conceivable that ions are heated effectively compared with electrons during the transport from the lobe to the plasma sheet. In the plasma sheet, however, the temperature ratios distribute over a wide range at a given plasma β. Besides, all temperature ratios at neutral sheet crossings do not show the highest values nearby the neutral sheet crossings. It suggests that ion and electron temperatures do not always represent analogous profiles and that variance in the temperature ratios could be caused by local conditions or by temporal variations.

S7-P04

ENERGETIC PARTICLE SIGNATURES OF RECONNECTION AND PLASMOID FORMATION IN THE MAGNETOTAIL

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Data from the High Energy Particle experiment - Low energy Detector (HEP-LD) and Magnetic Field Experiment (MGF) onboard the Geotail spacecraft has been used to study plasmoid structure released in the near-Earth magnetotail in association with magnetospheric substorms. Typical sizes of the plasmoids are in the range $3 - 9\ R_E$ and the deduced velocities are between $200 - 700$ km/s. The results suggest that solar wind input does not have any direct influence on the size or velocity of the plasmoid structures. The timing between processes in the tail and the corresponding signatures in the ionosphere or at geosynchronous orbit suggests that reconnection and plasmoid formation occurs in the late growth phase or onset of the expansion phase of the substorms.

S7-P05

FAST PLASMA FLOWS IN THE MID AND NEAR-EARTH MAGNETOTAIL: THEIR SPATIAL DISTRIBUTION AND IMF B_Z DEPENDENCE

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Statistics of tail plasma flows based on a large data set obtained by the GEOTAIL spacecraft have led to the following conclusions:
(1) Fast plasma flows found in the equatorial plasma sheet within the distance of 30 R_E are spatially limited to a narrow, wedge-shaped region centered at midnight. The local time extent of this fast flow region decreases with decreasing distance from the Earth and practically vanishes at $x = -15$ R_E.
(2) Significant deviation of flow direction from the Sun-Earth line occurs outside the fast flow region. The earthward flow is diverted either dawnward or duskward at the sides of the wedge-shaped region.
(3) The average earthward flow speed in the plasma sheet is not strongly dependent on Kp nor on IMF B_z. Fast earthward flows frequently occur in the wedge-shaped region even when Kp is low and IMF is directed northward. On the other hand, the wedge-shaped region itself expands in local time and extends nearer to the Earth when the IMF is directed southward.
(4) The north-south component of the magnetic field in the near-earth plasma sheet tends to be anti-correlated with IMF B_z, contrary to the notion that the magnetotail is stretched on average during periods of southward IMF. The stretched state of the magnetotail does not contribute much to the statistics of B_z since its duration is relatively short. The enhanced B_z in the plasma sheet during periods of southward IMF contributes significantly to the increased rate of earthward magnetic flux transport during periods of southward IMF.

S7-P06

CONSIDERATIONS REGARDING THE DRIVING OF FIELD-ALIGNED CURRENTS FROM THE EQUATORIAL MAGNETOTAIL

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Ensemble averages of the equatorial magnetotail pressure and field are obtained in order to determine in a statistical manner the location, magnitude and generation mechanism of region 1 and region 2 field aligned currents. We use plasma, energetic particle, electric and magnetic field data from 5 years of Geotail data. We derive the equatorial profile of ion pressure and magnetic field. We normalize the ion pressure for solar wind dynamic pressure fluctuations, and correct it for the superthermal ion component using energetic particle measurements. We derive the pressure gradient-driven currents using this technique. We also derive the flow - driven currents using the computed flow pattern from the same database. We check that against the flow pattern derived from the electric field measurements for consistency. The field aligned component of the current, thus computed from the divergence of the perpendicular current, agrees with ionospheric estimates of the region 1 and region 2 field aligned currents. The above work permits us to determine the location and driving mechanism of the ionospheric currents in the equatorial magnetotail.

S7-P07

GEOTAIL OBSERVATIONS OF THE TAIL MAGNETIC FIELD STRUCTURE

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In order to understand the ionosphere-magnetosphere coupling, it is important to know the magnetic field configuration in the magnetotail. The magnetic field model can provide the average magnetic field configuration in the magnetotail, however, it is well known that the magnetic field becomes more taillike in the substorm growth phase in the near-Earth magnetotail. Geotail has provided magnetic field observations at radial distances of $9 - 30$ R_E. There are several fortuitous cases in which geosynchronous spacecraft and Geotail are almost aligned in the same tail meridian near substorm onsets. For the 0655 UT, July 22, 1998 substorm, Geotail (at 9.2 R_E) and GOES 10 (at 6.6 R_E) were aligned almost in the midnight meridian and they observed substorm onset signatures. At 6.6 R_E, the observed magnetic field was comparable to the T96 model even before the onset. At 9.2 R_E, the magnetic field was only 12.7 nT just before the onset, and this value was much smaller that the T96 model value of 28.5 nT. Hence, the magnetic field was significantly taillike beyond the geosynchronous altitude. For substorm onsets in which westward electrojets are located near 66 geomagnetic latitude, Geotail frequently observes fast tailward plasma flows beyond 20 R_E. We have modified the T96 model with adding the strong tail current on the basis of magnetic field measurements in the magnetotail. We have found that the magnetic field line starting at 66 geomagnetic latitude on the ground reaches beyond 20 R_E in the magnetotail.

S7-P08

BURSTS OF FAST MAGNETOTAIL FLUX TRANSPORT

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Using data acquired by GEOTAIL at radial distances between 10 to 50 Earth radii in the central plasma sheet, we concentrate on events which are characterized by high flux transport rates. We found that these events are correlated with reconfigurations of the plasma sheet and, of course, exhibit strong similarities with the fast plasma flows which were described by other authors. The occurrence rate of earthward directed high flux transport events stays nearly constant and only drops significantly in the innermost region of 10 to 15 Earth radii distance. Probably, braking of the flows occurs close to the inner edge of the plasma sheet. Tailward directed events of high flux transport rates are largely consistent with tailward moving plasmoids that are generated at a magnetic neutral line situated earthward of the satellite. Generally, reconnection does not occur inside a distance of about 20 Earth radii. Reconnection activity is asymmetric to the midnight meridian with higher occurrence rates of enhanced flux transport in the pre-midnight sector.

S7-P09

COMPARISON BETWEEN TAILWARD FLOWS IN THE LOBE/MANTLE AND ION PRECIPITATION ONTO POLAR IONOSPHERE: GEOTAIL AND FAST OBSERVATIONS

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It is well known that a variety of particles precipitate into the Earth's ionosphere via a variety of processes. Precipitation of magnetosheath particles has been observed in the polar regions such as the cusp/cleft, plasma mantle, and lobe. Enhanced ion fluxes can be seen within the dayside polar cap near the magnetic separatrix (the boundary between open and closed magnetic field lines), and energy and flux of the precipitation decreases with increasing magnetic latitude especially during southward IMF periods. While it has been often assumed that the ion precipitation in the cusp consists of solar-wind protons, observations also show that magnetospheric ions trapped in closed flux tubes are precipitating at lower latitudes than the separatrix. In order to examine the fate of these particles after magnetic reconnection at the dayside magnetopause as well as the contribution of solar wind and ionospheric populations to the magnetotail plasma, we compared data from the GEOTAIL and FAST spacecraft, which observed the tail lobe/mantle and the low-altitude polar magnetosphere, respectively. The FAST observations show that there are regions where the magnetosheath and dayside plasma sheet/ring current components coexist and are precipitating together near the separatrix. In the open field line regions, the precipitating O^+ ions seem continuous with precipitation in the closed regions, while the H^+ and He^{++} precipitation becomes denser and less energetic in the open regions than the closed regions. The comparison of phase space density (PSD) utilizing Liouville's theorem shows that the PSD in the high-energy precipitation region on closed field lines can be comparable to that of tailward O^+ flows in the plasma mantle. From the statistics, it is also suggested that the trapped ions in the dayside magnetosphere are a potential source of ionospheric flows in the magnetotail at energies above 1 keV, while polar outflows from the cusp/cleft regions are the most probable source as for the flows below 1 keV.

S7-P10

RELATIONSHIP BETWEEN SUBSTORM MAGNITUDE AND SUBSTORM ENERGY STORAGE-RELEASE PROCESSES

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The purpose of this paper is to investigate in a model-independent manner the energy storage and release process of substorms as a function of both the position and the substorm magnitude. To carry out a statistical study, we identify substorm onsets on condition that the Pi 2 is simultaneously observed at three mid- to low-latitude ground stations along the 210 MM (magnetic meridian) or in South American region, when they are located near the midnight sector. In order to enable a clear recognition of the energy storage and release process, we choose substorm onsets with no other onsets in the preceding 30-min interval. As an index of the substorm magnitude, we use the amplitude of the positive bay observed at mid and low latitudes. As an index of the energy storage and release in the magnetotail, we use the total pressure obtained by GEOTAIL.

From over four years' worth of data we have identified about 250 substorms. We have classified the events by their magnitudes and occurrence areas and performed the superposed epoch analysis of the total pressure for each group. One of the results is that both the amount and the increasing rate of the energy in ($-15 < X < -6$ R_E, $-8 < Y < 8$ R_E) strongly depend on the substorm intensity. We have also found a difference of offsets in averaged total pressure profiles between large and small substorm groups. In order to understand this fact, we have examined solar wind dynamic pressure before the onsets. As a result, the solar wind dynamic pressure was larger for the large substorm group. Then we have been able to correct the difference of the offset by using the solar wind data.

S7-P11

DIFFERENCE OF PLASMA PROPERTIES IN THE LOW-ALTITUDES BETWEEN POSITIVE AND NEGATIVE IMF-B_Z CONDITIONS: STATISTICS OF AKEBONO OBSERVATIONS

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From Akebono observation at altitudes of several thousand km, particle precipitation in the polar region has been analyzed statistically. We studied two-dimensional flux distributions of precipitating electrons and ions for hourly conditions that IMF $B_z > 1$ nT and < -1 nT. It is found from two-dimensional maps that, ion precipitation of about 1 keV appears in the dawn/dusk regions only for the northward IMF period. Its energy range is lower than that of ion precipitation ($\sim$ 10 keV) appearing in the nightside region regardless of IMF B_z sign. We will report the difference of ion properties between the B_z signs investigated in detail. These properties are also controlled by the solar wind conditions. The ion precipitations with low- and high-energy ion precipitation are both originated in the plasma sheet. Thus, these properties expected to inform the difference of plasma sheet plasma between the IMF conditions. The problems are that the low-energy ions do not exist in the midnight region and that it disappears for the southward IMF. Since the region of the precipitation is projected onto the flanks of the magnetosphere using model field lines, its source is expected to occur in the flank region of the plasma sheet during northward IMF. This is supported by the direct observations in the plasma sheet in the magnetotail.

S7-P12

MANIFESTATION OF NONLINEAR RESONANT INTERACTIONS IN THE CURRENT SHEET: INTERBALL-1 BEAMLET OBSERVATIONS

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Interball-1 plasma instruments permanently register short-lived (tens of seconds) bursts of the highly accelerated ions (> 10 keV) moving both Earthward and tailward (more rarely) at the outer Plasma Sheet (PS), PSBL and within tail lobes. Properties of these ion bursts are consistent with the theory prediction (*Ashour-Abdalla et al., JGR*, **98**, 5651, 1993; *JGR*, **100**, 19191, 1995;) about small-scale spatial structure of PSBL flows. Localized ion beams (called beamlets) were explained as the result of sequential resonant/nonresonant interactions of mantle ions with the different regions of the distant current sheet (CS). At specific "resonant" locations where chaotic scattering is reduced ions after gaining substantial directed energy get access to the PSBL. Ions interacting with CS at other locations populate the PS because their acquired energy is thermalized due to large chaotic scattering. In real situation which is much more complex than the model, mantle ions are interacting with the structured ("fragmented") distant current sheet (*Zelenyi et al., New Perspectives in the Earth's Magnetotail*, **105**, 321–338, 1998) and short duration of the beamlet observation is related with the finite size of the resonant acceleration sites (few ion Larmor radii). Statistics as well as the characteristic shapes of beamlet velocity distributions conform well with this explanation. Another type of transient structures which could be observed within the lobes quite far from the CS is the quasi-isotropic clouds of plasma with the properties resembling the one in central PS. These events are related with the ejections of the plasma filaments from the PS, which could be caused by large-scale Kelvin-Helmholtz type instabilities or structural reconfigurations of the cross-tail current system.

S7-P13

RELATIVE TIMING OF MAGNETOTAIL PHENOMENA AND AURORAL BREAKUP: IMPLICATION FOR THE SUBSTORM ONSET LOCATION

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Several cases when Geotail satellite in the mid-tail observed the high-speed tailward plasma flows associated with bipolar variations of the magnetic field B_z-component (plasmoids) are considered. The selection criterion for these cases was an existence of the ground based auroral observations. For several events auroral observations from space (performed by the Polar imagers) were also available. The auroral data showed that all plasmoids followed the auroral breakups, which mark the substorm onset. Under reasonable suggestions on the plasma sheet properties along the tail and using the measured values of the plasma flow velocity, the tracing back of plasmoids has been done. The tracing locates the source of plasmoid at distances $10 - 20\ R_E$. Within uncertainties related to unknown delay between the aurora brightening and breakup-related magnetospheric process, estimated time of the plasmoid generation is close to the time of breakup. Near-Earth location of the substorm onset source is also confirmed by consideration of the well-documented event for which the event-oriented magnetospheric model has been constructed. The mapping made on the basis of this model also placed the pre-breakup arc into the near-Earth region ($r = 10 - 15$ R_E). At these distances the model predicts the presence of a thin and intense current sheet.

S7-P14

CASE STUDIES OF MAGNETOTAIL VARIATIONS AND AURORAL ACTIVITIES DURING SUBSTORMS

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We have studied relationship among magnetotail variations, auroral breakups, and Pi 2 pulsations during substorms, using GEOTAIL, Polar/UVI, and ground magnetic field data. We found that the auroral breakups and the Pi 2 pulsations were highly correlated with fast plasma flows with the variations in the north-south magnetic field and the total pressure in the magnetotail. In a substorm, several fast tailward flows were observed with the southward magnetic field and the total pressure enhancement around $X = -20\ R_E$ in association with the plasmoids about 1 min after or simultaneously with the auroral breakups, including the auroral intensifications (pseudobreakups). In the late expansion phase, fast earthward flows were observed with the northward magnetic field and the total pressure enhancement slightly earlier than the auroral intensifications. The auroral breakups and intensifications were accompanied by the Pi 2 pulsations on the ground within 1 or 2 minutes in most cases. Furthermore, we found that the total pressure in the magnetotail was largely decreased after its enhancement, corresponding to the onset of the auroral breakup or the expansion of the auroral bulge, while the total pressure was enhanced and then decreased only a little in the pseudobreakup.

S7-P15

GENERATION OF BURSTY BULK FLOWS BY RECONNECTION AND FLOW BRAKING

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We have investigated the spatial and temporal development of Bursty Bulk Flows (BBFs) created by the reconnection as well as flow braking in the near-Earth tail using our 3-D global EM particle simulation. As the solar wind with the southward IMF advances over the Earth, the near-Earth tail thins and the sheet current intensifies. Before the peak of the current density becomes maximum, the reconnection takes place, which ejects particles from the reconnection region. Because of the earthward flows the peak of the current density moves toward the Earth. The characteristics of the earthward flows depend on the ions and electrons. Electrons flow back into the inflow region (the center of reconnection region), which provides current closure. Therefore the structure of electron flows near the reconnection region is rather complicated. In contrast, the ion earthward flows are generated far from the reconnection region due to the large gyroradius. These earthward flows pile up near the Earth. The ions mainly drift toward the duskside. The electrons are diverted toward the duskside. We will investigate the acceleration of particles due to the dipolarization. The earthward ion flows are rather confined in the plasma sheet, which may be consistent with the preliminary test particle simulations using a dipolarizing magnetic field. We have examined the ionospheric consequences. Due to the coarse resolution near the Earth without a realistic ionospheric model in our simulation to discuss on the wedge current is difficult. The simulation results show that the more high energy particles are injected into the inner magnetosphere (ionosphere).

S7-P16

RECONNECTION AND CONVECTION MEASUREMENTS FOR DIFFERENT DEGREES OF SOLAR WIND-MAGNETOSPHERE COUPLING

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Reconnection is a fundamental aspect of the solar wind coupling to the magnetosphere-ionosphere system. As a result of this coupling, energy and momentum in the magnetosphere are circulated through a variety of mechanisms. These mechanisms have been well characterized by in-situ satellite measurements in the magnetotail, but have not been well correlated with global reconnection estimates of geoeffectiveness. We have combined POLAR UVI and VIS images with ionospheric convection and GEOTAIL and geosynchronous measurements of plasma, magnetic field and electric field to quantify the cycle of dayside/nightside reconnection (and the concomitant polar cap inflation and deflation) and its correlation with changes in the magnetotail convection, for various degrees of solar wind-magetopause coupling. To quantify merging and reconnection rates along the polar cap boundary, we have developed an algorithm that combines polar cap boundary estimates from POLAR UVI, VIS images with radar-based and AMIE-based maps of ionospheric convection. This technique has made possible for the first time simultaneous measurements of the reconnection rates everywhere along the boundary of the polar cap. We have identified a number of periods with northward IMF, weakly sothward IMF, steady southward IMF, and storm conditions. Periods of enhanced solar wind-magnetopause coupling, such as those occurring during "steady magnetospheric convection" periods and storms produced by interplanetary magnetic clouds, have a time scale of inflation-deflation of $3 - 3.5$ hours. They show also extended periods of positive correlation between the magnitude and rate of ocurrence of bursty bulk flow events and the amplitude and peak frequencies of the magnetospheric cavity and waveguide pulsation modes, and the amplitude and peak frequencies of pulsating aurora.

S7-P17

MAGNETIC FIELD CONFIGURATION AND PLASMA FLOW IN THE NEAR-EARTH MAGNETOTAIL DURING STORM TIME: GEOTAIL OBSERVATIONS

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Although comprehensive magnetic field surveys of the magnetosphere have been made for many years, magnetic field configuration changes in the near-Earth magnetotail during a severe magnetic storm have not yet been examined in detail. From recent GEOTAIL observations in an ascending phase of the solar activity we obtained near-Earth magnetotail data from GEOTAIL for five magnetic storms when *Dst* indices were less than -100 nT. WIND data in the magnetosphere are also available for one of these events on November 13, 1998. We will discuss magnetic field configurations and plasma flows observed in the dusk-midnight sector around distances of 10 R_E (earth's radius) from the Earth ($3 < X_{GSM} < 10$, $0 < Y_{GSM} < 10$) . It is found that the B_y and B_x components are dominant as compared with the B_z component near the equatorial plane during storm time, while the dominant contribution to the field magnitude is B_z in quiet periods. Namely, magnetic fields were highly stretched , but were not in radial direction. The magnetic field direction inclines tailward by $30 - 45$ degrees in local time sector of $16 - 21$ hour. The field magnitude sometimes exceeds 100 nT in this local time sector. The results will be discussed, referring to the Tsyganenko model.

S8-01

THE IMAGE MISSION – GLOBAL VIEWS OF A GEOMAGNETIC STORM

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The application of remote sensing techniques has a high potential of obtaining unprecedented space weather related data on the dynamics of storm and substorm processes and in particular determining the relationship between a variety of phenomena. The Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) mission has an impressive array of remote sensing instruments which are imaging a number of important phenomena such as the auroral zone, the geocorona, the ring current, the plasmasphere, and the auroral ion fountain on a time scale of 10 minutes or less. On March 25th, IMAGE was placed into a polar orbit with apogee of about 7 Earth radii (R_E) and inclination of about 45 degrees. At this location it is well situated to observe the structure and dynamics of a number of magnetospheric boundaries over periods of several hours during geomagnetic storms. This paper will provide an overview of some of the early measurements from the IMAGE instruments illustrating many aspects of global geomagnetic storm dynamics.

S8-02

THE POLAR VIEW OF THE STORM-TIME RING CURRENT

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S8

A review is given of the observations of the storm-time ring current ions by the ISTP Polar satellite. The CAMMICE Magnetospheric Ion Composition Spectrometer (MICS) provided mass and charge state composition data for energetic (125 keV/e) positively-charged ions. Two aspects of the storm-time ring current ion populations are described. These include a statistical analysis of the ion flux measured by CAMMICE MICS to test the Dessler-Parker-Sckopke relation. This theory relates the global energy content of charged particles in the magnetosphere and the average perturbation magnetic field at the Earth's surface. The results are compared with a recent, similar study of AMPTE/CCE data by Greenspan and Hamilton (2000). The ions pitch angle distributions observed by CAMMICE MICS are used to assess the loss rate of major ion species during storm recovery phase. This is done by constructing the local pitch angle distributions for several consecutive satellite passes through a given L value and mapping the distributions to a common latitude using the measured magnetic field magnitudes. This is more model independent than mapping all the distributions to equatorial pitch angles. The results of this study are compared with *Chen et al.* (1999), which compared proton pitch angle distributions computed by a transport simulation model with the proton measurements by a similar instrument on the CRRES satellite.

S8-03

A SIMULATION SCHEME FOR HIGH ENERGY PARTICLES IN THE INNER MAGNETOSPHERE: *Dst* AND THE RING CURRENT FORMATION

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A numerical simulation model of the ring current in the magnetosphere has been developed. By tracing newly injected ions with various pitch angles and energies under a dipole magnetic field and the convection electric field depending on the solar wind velocity and IMF, we calculate three-dimensional distribution of a directional differential flux of energetic ions, plasma pressure and current density. If we assume the source region in the near earth plasmasheet around $L \sim 8$, not only an enhanced convection but also an inductive electric field may be required to push the energetic particles to the region around $L = 5$ at the substorm onset. The magnetic disturbance due to the ring current can be directly obtained by the Biot-Savart integral of the current density. The response of the storm-time *Dst* to the solar wind is examined : (1) In the main phase there are two-step decays of *Dst*. Its early stage is due to the enhancement of the convection field while the subsequent steep decrease is produced by the plasma sheet density enhancement. (2) The recovery phase also consists of two-steps. The early recovery is due to the decrease in plasma sheet density, particles' outflows and redistribution of particles while the latter is mainly produced by the charge exchange loss process. (3) There is a time lag between solar wind density and plasma sheet density. DPS (Dessler-Parker-Sckopke) theory is also examined.

S8-04

THE ROLE OF THE LARGE SCALE ELECTRIC FIELD IN THE DYNAMICS THE RING CURRENT

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The CRRES spacecraft in a geosynchronous transfer orbit with a orbital period of $\sim$10 hr has provided the first information on the dynamics of the large spatial scale electric fields and substorm electric fields in the inner magnetosphere during major geomagnetic storms. These observations on the dusk side demonstrate that the large spatial scale convection electric field penetrates deep in to the inner magneto-sphere to between $L = 2$ and $L = 4$, with magnitudes up to 7 mV/m and electric potential drops up to 70 kilovolts on the dusk side earthward of $L = 4$ and earthward of the inner edge of the plasmasheet. This potential drop is likely a underestimate of the total potential drop across the inner magnetosphere since only the dusk side has been sampled for these estimates. These enhancements are strongly associated with the main phase of major geomagnetic storms and are observed at the position of signatiures of ring current injection energization in particle data.For dusk passes of the CRRES spacecraft through the inner magnetosphere during major geomagnetic storms,the large scale convection electric fields is greatest earthward of the inner edge of the plasma sheet and coincides with fluxes of > 100 keV O^+ and H^+ ring current ions.During major geomagnetic storms, transient substorm electric fields reach amplitudes of > 10 mV/m and penetrate earthward to $L = 5$. They repeat on much faster time scales during major geomagnetic storms (30 minutes) than less active periods ($\sim$ 3 hours).

S8-05

RETHINKING THE ROLE OF SOLAR WIND NUMBER DENSITY IN RING CURRENT DEVELOPMENT

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In recent years several studies have suggested that the solar wind number density directly drives the terrestrial ring current. It has been argued that solar wind plasma enters the magnetosphere along the flanks and through the tail. This plasma then convects earthward into the plasma sheet and ultimately provides an enhanced source of ring current plasma. This paper will describe some new empirical analyses which call this paradigm into question. In particular, the reported correlation between solar wind number density and minimum Dst is shown to be absent during solar maximum in general, and disorganized or absent at solar minimum. Various superposed epoch analyses will also show that the solar wind number density is not an effective ring current driver independent of or in concert with southward Interplanetary Magnetic Field.

S8-06

ROLES OF CONVECTION AND SUBSTORM ELECTRIC FIELDS ON RING CURRENT GROWTH

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The responses of the ring current to enhanced large-scale convection versus substorm convection surges are investigated. A kinetic model of the inner magnetosphere is used to solve the ion distribution in the ring current region with the boundary fluxes at 10 or 12 R_E calculated by backtracking particles to their source regions in the magnetosphere. Two types of magnetic reconfigurations are simulated. First we simulate a substorm cycle by slowly varying the Tsyganenko 89 magnetic field model from a quiet configuration to a more disturbed one, and then quickly returning it to the initial state. This represents a global simultaneous reconfiguration of the magnetosphere. The second simulation we employ the magnetic and electric fields generated from a MHD model during a IMF southward turning, in which the magnetotail goes through elongation, formation of neutral line and the subsequent dipolarization. The reconnection in the magnetotail initiates in the dawn-midnight sector and then extends to the pre-midnight sector. We will address the roles of convection and substorm-induced electric fields on ring current development during these two magnetic reconfigurations. Effects of structure and local dynamics in the MHD fields will be determined through comparison with the averaged empirical fields. The different behaviors of ring current H^+ and O^+ will be discussed.

S8-07

MODELING INNER MAGNETOSPHERIC CONVECTION AND RING CURRENT EVOLUTION DURING MARCH 10 – 12, 1998

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A stream-stream interaction region observed by the WIND spacecraft from $\sim$ 12 UT to $\sim$ 24 UT, March 10, 1998, triggered a major geomagnetic storm which peaked within few hours at $Dst \sim -126$ nT and $Kp = 7+$. During the main phase of this storm the north-south component (B_z) of the IMF was large and negative (-15 nT). Thereafter, a 5-day-long Alfvén wave train on the faster stream in which B_z fluctuated about zero with a peak-to-peak amplitude of $\sim$ 6 nT lead to lower level activity with an average $Dst \sim -50$ nT, after which a recovery took place. We simulate the stormtime injection and trapping of H^+, O^+, and He^+ ring current ions using our kinetic drift-loss model [*Jordanova et al.*, 1996, 1998] and initial and boundary conditions specified by measurements from the ESIC instrument on Equator-S, the HYDRA instrument on POLAR, and the MPA and SOPA instruments on the LANL spacecraft. The results employing two formulations of the inner magnetospheric convection are compared: (a) the 3-hour averaged, Kp-dependent, traditional Volland-Stern model; and (b) the IMF-dependent model of *Weimer* [1996], where we input IMF data at $\sim$ 30 min resolution. We find that while both convection models reproduce the main trends of ring current evolution and show reasonable agreement with data at larger L shells, the agreement between model and data is significantly improved at lower L shells and on the dayside when the Weimer model is used.

S8-08

NUMERICAL SIMULATIONS OF O^+ ACCELERATION IN A POTENTIAL WELL

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It has been shown that during great storms the ring current is dominated by singly ionized oxygen originating in the terrestrial ionosphere. We have not yet completely understood the mechanisms of acceleration and transport of O^+ from the ionosphere to the equatorial magnetosphere and its injection to the ring current. Relevant investigations are a critical part of magnetic storm research. Here we present numerical simulations of the acceleration of singly ionized oxygen ions in a potential well. The potential has an exponential form in the x-direction with a characteristic scale Lx. The ions move in the presence of a constant magnetic field B_z and a constant perpendicular electric field E_y. The electric field provides the particle drift in the x-direction and allows the interaction between ions and potential well. We trace the orbits of individual ions for different initial conditions (phase angle and initial kinetic energy). Depending on the initial conditions, ions can be accelerated or decelerated. In addition we perform a parametric study for the interactions of monoenergetic and Maxwellian-type particle distributions with respect to our model parameters, such as the characteristic length (L_x) and the background electric field (E_y). For this part of the study we use random phase angle injection for the particles. We present and discuss the results of our simulations.

S8-09

INFLUENCE OF EMIC WAVES ON RING CURRENT DYNAMICS

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Electromagnetic Ion Cyclotron (EMIC) Waves are generated in the outer magnetosphere by cyclotron resonant interaction with ring current protons. During storm conditions, when the ring current proton population is enhanced, the waves can attain amplitudes above 1 nT. This is sufficient to cause resonant pitch-angle scattering at the strong diffusion rate and consequently leads to intense precipitation loss to the atmosphere. Excited waves can also interact with the Oxygen component of the ring current leading to perpendicular heating and O^+ energization during the main phase of a storm. Numerical simulations of the evolution of the ring current, and the concomitant excitation of EMIC waves during a storm, indicate that the duskside region near the plasmapause is a favored region for wave growth. The interaction of such waves with the ring current population can lead to significant energy diffusion and may consitute an important loss process during certain phases of a storm.

S8-10

INFLUENCE OF IONOSPHERIC OXYGEN IONS ON PLASMA SHEET AND RING CURRENT DYNAMICS

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Ionospheric-origin singly charged oxygen ions constitute an important part of the ring current and the near-Earth plasma sheet region during storms and substorms. When sufficiently strong energetic oxygen ion fluxes are built up in the near-Earth plasma sheet region, they can drive a helicon mode instability. The helicon wave instability can facilitate excitation of the ion tearing modes, leading to substorm onset. As a result the oxygen ions could be injected towards the Earth's nightside magnetosphere. In the ring current region, trapped energetic oxygen ions having loss-cone distributions can excite quasi-electrostatic ion loss- cone instabilities. The turbulence generated by these instabilities may cause pitch angle scattering of ring current ions into the atmospheric loss cone, thus leading to ring current decay.

S8-11

STORM-SUBSTORM RELATIONSHIP AND RING CURRENT GROWTH

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Substorms and storms are perhaps most widely studied using the auroral electrojet index *AL* and storm time index *Dst*, respectively. Their relationship also is studied using these indices and other relevant solar wind variables. The indices are constructed in different ways, viz. *AL* is an envelope whereas *Dst* is an average. Consequently the details preserved, as well the information loss, are different in these indices. The data from the ground magnetometers in the high and mid-latitude regions can be used directly to overcome some of the limitations. The time scales of magnetospheric dynamics are studied using the high resolution (5 min) time series data of the *AL* index and of the high-latitude magnetometers for the period January – June 1979. Considering the inherent nonlinearity of the magnetosphere, the average mutual information (AMI), which yields the coherence or memory time before dynamical information is lost, are computed from the time series data . The AMI for quiet and active periods are computed from the *AL* and the magnetic field measurements at 11 magnetometer stations. For active periods the coherence time for *AL* is less than 10 min and for the individual stations it ranges from 10 min to 30 min, thus showing considerable loss of information when *AL* is used instead of the magnetometer data. However for quiet periods the AMI for *AL* lies within the range of values for the magnetometer stations. The same behavior is found for the *Dst* and the *H*-components from the contributing stations. The *Dst* is predicted using nonlinear dynamical techniques from the magnetic field measurements in the auroral region to study their cause-effect relationship. The effects of solar wind magnetic field and dynamic pressure are also studied by using them as input variables. The predictability is found to be different for different stages of a storm, indicating the varying roles of substorms in the ring current development.

S8-12

RING CURRENT OBSERVATIONS DURING THE INTENSE STORMS OF 1991

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We present observations of the storm-time ring current by the Combined Release and Radiation Effects Satellite (CRRES) during the previous solar maximum. In particular, we have studied the ring current during several moderate and large magnetic storms that occurred from February to July 1991. The measurements show that the ionospheric-origin O^+ contribution to the ring current is proportional to the storm intensity, as represented by the *Dst* magnitude. This *Dst* - O^+ relationship was evident in all moderate to large storms during 1991. During the particularly great storm in March 1991, the dominance of O^+ around the maximum of the main phase was the greatest observed. The O^+ contribution to the total energy density was close to 80 % in the *L*-range 5 to 6. This level is to be compared with a mere 10 quiet-time contribution of O^+ to the total energy density. We discuss the implications of these severe compositional variations for storm dynamics and for the storm-substorm relationship. Furthermore, we discuss the influence of solar drivers of magnetic storms on the massive ionospheric outflow during intense magnetic storms.

S8-13

INFLUENCE OF SOLAR WIND VARIATIONS ON IONOSPHERIC OUTFLOW

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The solar wind, once thought to be the principal source of magnetospheric energetic plasma and auroral particle precipitation, is now known to produce a net escape of ionospheric plasma into the magnetosphere, by dissipating energy within the topside ionosphere. Reconnection of solar wind magnetic field lines with the geomagnetic field lines vigorously circulates ionospheric plasmas throughout a region identified as the geosphere, whose shape is strongly influenced by the interplanetary field orientation. The region of ionospheric dominance extends well beyond the classical plasmasphere, within which ionospheric plasma was once thought to be fairly well contained. The extent of the geosphere depends upon the flux of solar EUV radiation falling on the neutral atmosphere, reflecting solar cycle variations, and upon the character of the solar wind, usually reflected in the level of geomagnetic activity. Through the ISTP program, it has been learned that the solar wind factor that most strongly drives ionospheric outflow mass flux is the dynamic or ram pressure. The solar wind ram pressure affects the magnetosphere by causing changes in the magnetopause location, and by changing the rate at which momentum is transferred to the magnetosphere via reconnection. Paradoxically, the more the solar wind compresses the magnetosphere, the more the geospheric region expands, until the ionosphere dominates all but the magnetospheric boundary layers and the distant magnetotail. We summarize current knowledge and describe work designed to reveal the mechanism of dynamic pressure variations in producing enhanced field aligned currents, ionospheric heating and outflow, and its potential effects on the storm time ring current.

S8-14

THE BUILDUP OF IONOSPHERIC IONS IN THE MAGNETOSPHERE DURING STORMS AND THEIR ROLE IN THE FORMATION OF ENERGETIC POPULATIONS IN THE RING CURRENT

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During storms the flux of heavy ionospheric ions flowing out into the magnetosphere is often observed to be strongly enhanced. These heavy ions can experience preferential acceleration and can become the dominant component in the ring current particularly at high energies. The production of enhanced ionospheric outflows during a storm is modeled through multi-fluid simulations that separately tracks the dynamics of the solar wind ions, and different ions species from the ionosphere. It is shown that while jumps in the solar wind dynamic pressure leads to temporary enhancements in the ionospheric outflows,persistent southward or dawn-dusk interplanetary magnetic field produces sustained ionospheric outflows that can reach the deep tail. These enhanced flows are shown to be associated with changes in ionospheric conductivity. Heavy ions in these flows are show to be preferentially accelerated so that they can become the dominant component at high energies over significant regions of the magnetosphere. Single particle trajectories are then used to look at the energy distribution of particles forming the ring current.

S8-15

ION COMPOSITION CHANGE IN THE NEAR-EARTH PLASMA SHEET DURING MAGNETIC STORMS

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It has been reported that the ion composition of the ring current changes drastically during the main phase of magnetic storms. The ion composition measurements by the AMPTE/CCE and CRRES satellites have shown that H^+ ions are dominant during quiet times, while O^+ ions are an important constituent in the ring current energy density during storms. However, the cause of strong enhancement of O^+ constituent during storms is still a subject of debate. In the present study we use Geotail/EPIC observation of energetic ions ($9 - 210$ keV) during storms. We examine the energy density ratio of O^+ ions to H^+ ions in the near-Earth plasma sheet ($X = -9$ to -15 R_E). From analysis of storms occurred in 1998, we found that the energy density ratio increased up to $\sim$1.0 during storms, though the ratio was $\sim$0.1 during quiet times. These results are consistent with those in the ring current ($L < 7$), thus the near-Earth plasma sheet is thought to be a direct source of ring current plasma. We discuss how O^+ ions are strongly accelerated in the plasma sheet and supplied to the ring current.

S8-16

RING CURRENT ESTIMATED FROM LOW ALTITUDE OBSERVATIONS

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When energetic protons are injected into the Ring Current they will also appear at low altitudes in the midnight/evening sector reaching down to mid-latitudes. These precipitating protons have been analyzed during several geomagnetic storms using data from low altitude polar orbiting satellites. Based on these data the proton injection rate into the Ring Current is determined. We argue that the total power of precipitating protons below $L = 4$ is proportional to the ring current injection rate. Using this as a source and charge exchange as a loss mechanism the *Dst* has been estimated for a number of geomagnetic storms. During geomagnetic storms highly localized regions of enhanced proton (ion) precipitation in the tens to several hundreds keV energy range, can appear at mid-latitudes. The L-dependence of the ion enhancement throughout the storm was similar to the Kp dependence of the location of the plasmapause. These ion enhancements represent a loss of Ring Current protons and this loss has been estimated for the storms considered.

S8-17

THE TEMPORAL AND SPATIAL DEVELOPMENT OF THE RING CURRENT DISTURBANCE FIELD DURING THE GEM STORMS: OBSERVATIONS AND MODEL SIMULATION

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The University of Michigan Ring Current-Atmospheric-Interaction Model has been utilized to model the temporal and spatial development of the low latitude ground magnetic disturbance field produced by the ring current for the GEM magnetic storms: May 15, 1997, September 24 – 25, 1998, and October 18 – 19, 1998. The model results have been directly compared to the spatial and temporal development of the disturbance field measured by a longitudinal chain of approximately 18 – 20 midlatitude magnetic observatories. We find that the model reproduces much of the symmetric and asymmetric disturbance field. Further, we examine the simulation to determine the individual contributions to the disturbance field which are produced by field-aligned currents, perpendicular ring current and the ionospheric closure current. The observations show, at times, considerably more structure than the simulation output. Some of this may be accounted for by the use of a static dipole field (no pressure variation), a simplistic method for specifying the cross magnetospheric convection electric field, and by substorm signatures which are not accounted for in the simulation.

S8-18

JUNE 4 – 5, 1991 MAGNETIC STORM: A CASE STUDY

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We use the Rice Convection Model to conduct a detailed study of inner magnetospheric plasma dynamics during the well-observed magnetic storm of June 4 – 5, 1991. We concentrate on elucidating the development of the inner magnetosphere shielding electric field, the injection of plasma sheet particles to form the storm-time ring current, and the fate of the pre-storm ring current population. Extensive comparisons are made between model results and plasma data from the CRRES Magnetospheric Ion Composition Spectrometer. In addition, electric field data inferred from the DMSP ion drift meter and the CRRES electric field instrument are compared with RCM-calculated electric fields.

S8-19

STORM GEOEFFECTIVENESS AND RING CURRENT MODELING OF THE SEPTEMBER 1999 CAMPAIGN STORMS

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A kinetic ring current model has been used to simulate the energetic ion population in the inner magnetosphere during the geomagnetic storms of the September 1999 S-RAMP Space Weather Month Campaign. The modeled ring current energy budget is compared against the energy input functions and other energy deposition values for the events, such as the precipitation energy input and Joule heating energy input as calculated by the AMIE model. In addition, results from the model are compared with in situ satellite data as well as ground-based magnetometer data to elucidate the structure and dynamics of the ring current during these events. In particular, the differences between the geoeffectiveness of the events are examined, comparing the high-speed stream events against each other and also against the two larger storms in late September and October. Magnetometer comparisons include not only the standard bulk comparisons with Dst, but also individual station comparisons of the ring current perturbation from a Biot-Savart law integration of the model results.

S8-20

WAVE STRUCTURE OF THE POLARIZATION JET AND RING-CURRENT ION PRECIPITATION DURING SEVERE DISTURBANCES

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During disturbed conditions, a region of polarization electric field forms at sub-auroral latitudes in the pre-midnight sector, where the storm-enhanced ring current particle populations overlap the outer regions of the plasmasphere. This electric field and the particle populations associated with its formation are an integral component in the shielding of the inner magnetosphere from the high-latitude disturbance electric field. At ionospheric heights, a polarization jet (PJ) of sunward plasma convection with velocities > 2000 m/s ($|E| > 100$ mV/m) and spanning several degrees of latitude is known to occur at increasingly lower latitudes as Kp increases. In general, the electric field varies smoothly across the PJ, which is easily identifiable as a separate region of strong sunward convection equatorward of auroral latitudes. Recent observations with the DMSP Ion Drift Meter and ground-based radars indicate that considerable wave-like structure develops in the region of the PJ during the most-intense disturbances. An electromagnetic wave, likely Alfvénic, with periodic electric and magnetic field variations of up to 75 mV/m and 100 nT is observed to develop across the PJ. The magnitude of the smoothly-varying polarization electric field is decreased in the region of waves occurrence. Energetic (ring current) ions with $E > 30$ keV are seen in a one-to-one association with the occurrence of the PJ waves and are presumed to be related to occurrences of red aurora at mid latitudes during such events. The PJ waves are observed in both hemispheres in the pre-midnight sector for a two-hour interval during the April 6/7, 2000 storm event. We investigate the conditions at the inner edge of the ring current leading to a breakdown of a uniform region of polarization electric field into a wave-like structure, and the implications of this phenomenon on inner magnetospheric shielding during severe storms.

S8-21

LOCAL TIME MAGNETIC FIELD PERTURBATIONS FROM THE RING CURRENT: COMPARISONS OF OBSERVATIONS AND THEORY

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Maps of the local time dependence of the midlatitude magnetic field perturbations during the June 4 – 7, 1991, geomagnetic storm have been constructed, revealing large asymmetries and many fine-scale structures in the maps. Deconvolution of these maps has been performed using a couple of modeling techniques. Firstly, the results from a ring current simulation have been numerically integrated according to the Biot-Savart law to obtain perturbation values at the stations. These maps also show asymmetries and are able to explain many of the large-scale structures in the observations. Secondly, perturbation values have been computed from AMIE results, showing the influence of the high-latitude ionospheric current systems on the midlatitude stations. Furthermore, the AMIE and ring current model are compared to understand the nature of the partial ring current closure current systems and how they influence the ground-based magnetometers. Data-theory omparisons are shown for both the latitudinally-averaged LT-UT maps as well as for individual station locations. A discussion is also presented about those features remaining unexplained by the two model simulation results.

S8-22

RELATIONSHIP OF THE RING CURRENT TO *Dst*

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Due to the important role the ring current plays in magnetospheric energetics, it is essential to understand its strength and evolution in disturbed times. There are currently three main methods for deducing the strength of the ring current: measuring ground magnetic perturbations, measuring high-altitude magnetic perturbations, or directly measuring ring current particles. The use of ground magnetometers is the most convenient, and many use the ground magnetometer-derived *Dst* index as a proxy for the ring current. Recent work suggests, however, that a substantial portion of *Dst* may not be caused only by the ring current, but also by local induction effects or other magnetospheric currents, so simply using the *Dst* index may yield inaccurate results. In this study, we model the contribution of the tail current to *Dst* using modified Tsyganenko magnetic field models. To do this, we isolate a tail region in the model and subtract its effect from a modeled *Dst*. Using results from this modeling and work by others concerning induced ground currents, we compare *Dst* to particle measurements from the CAMMICE/MICS detector on Polar for two years of data. We find good agreement with the Dessler-Parker-Sckopke relation for these data once ground, tail, and magnetopause currents are taken into effect. Ring current ions are shown in this analysis to contribute, on average, half of the *Dst* depression, with a large variety among individual events.

S8-23

SINGLY CHARGED OXYGEN AS A PROXY FOR *Dst*

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The Spacecraft-Charging at High Altitudes (SCATHA) spacecraft was launched into a near-geosynchronous orbit in January 1979. The spacecraft instrument complement included an ion composition experiment that could measure ions in the energy range from 100 eV/q to 32 keV/q. A survey of the ion composition data acquired in 1979, near the peak of solar cycle 21, shows a significant correlation between the energy density of singly-charged oxygen and *Dst*. The correlation between *Dst* and proton energy density is much weaker. While the ring current is typically thought to be carried by higher energy ions, and *Dst* is itself a poor measure of the ring current, the correlation appears to indicate that plasma of ionospheric origin is a significant contributor to the ring current. It is less clear if the ionospheric plasma has been recently injected in forming the ring current, or if the plasma has been resident for some time within the magnetosphere. In the latter case, however, we would expect that the protons would show a correlation with *Dst* similar to the oxygen ions.

S8-24

STORM-TIME RING CURRENT AS A "DRIVER" OF *Dst*

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The most widely used measure of storm intensity is the *Dst* index, which is constructed from magnetograms of several low-latitude stations, and involves deviations in the horizontal H component of the geomagnetic field from quiet-time values. *Dst* can also be calculated from energetic ion measurements of the ring current, using the Dessler-Parker-Sckopke (DPS) relation. The first one we will call the "observed" and the second one the "estimated" *Dst* index. In this paper we will compare the two indices for two intense magnetic storms in 1991, namely the June 5, and July 8 – 13 storms. Those storms reached observed minimum *Dst* levels of −200 to −270 nT. We shall use energetic ion measurements from the Combined Release and Radiation Effects Satellite (CRRES) and the Dessler-Parker-Sckopke relation, in order to derive the "estimated" *Dst* index due to the ring current. The comparison of "observed" and "estimated" *Dst* reveals differences, which are attributed to two factors: the inherent limitations of the particle measurements, and the influence of magnetospheric current systems other than the ring current on ground geomagnetic disturbances. We shall furthermore investigate the contribution of each detectable ion species to the *Dst* modulation, and compare to each other. For intense storms it has been previously shown that the *Dst* profile has a similarity with the profile of the contribution of O^+ ions to the ring current energy density. Here we show that the "contribution" of O^+ to the *Dst* profile, as calculated through the DPS relation, is closely matching the *Dst* profile itself around storm maximum.

S8-25

MAGNETIC DISTURBANCES RESTORATION ON LOW LATITUDE MAGNETIC STATIONS BY ARTIFICIAL NEURAL NETWORK TECHNIQUE

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The artificial neural networks (ANN) technique was applied for restoration of records of disturbances of horizontal component of geomagnetic field on chosen low latitude magnetic station (output) by magnetic stations (input) located near geomagnetic equator. For this purpose, recurent ANN with back propagation of error was used. As a processable material, the magnetic data received at magnetic stations Kakioka, Kanoya, Alma-Ata, Hermanius, San Juan, Tacson, Honolulu in 1979 were selected. As a result, 433 data hours without failures for training of ANN and 2083 hours for quality check of its work were chosen. Thus, the magnetic daily variation is eliminated by original change of chosen ANN architecture. The research of dependence of restoration error on number of input stations, their location and quantity of hidden units was carried out. The restoration of normalized horizontal component of magnetic disturbances at 6 hidden units at Kakioka station by the records of others 6 stations occurs with a 95 objective estimation of quality. It is better, than direct data replacement on Kakioka station by near located Kanoya station. In case of restoration of horizontal component at output station by one input station, the quality falls with increase of distance between them. With increase of neuron quantity in the hidden layer, the quality of restoration is increased. It is especially well seen for the restoration of records at Alma-Ata magnetic station by one Kakioka station. The increase of hidden neuron number from 6 to 20 is following by restoration quality growing from 48 up to 58 The increase of the hidden units more than 24 becomes inefficient. The introduction of a delay line in network architecture improves restoration on the average 5 The improvement of magnetic disturbances restoration, not connected with daily variation is marked when introducting simultaneous data on concentration and solar wind velocity, and also B_z components of the interplanetary magnetic field in number of input units for ANN. The created ANN program also with good accuracy allows to carry out the forecast of dependence of asymmetry of ring current on time, from the moment of SC magnetic storm, using the data received on OMNI satellite system.

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S8-26

VARIABILITY OF THE RING CURRENT SOURCE POPULATION

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Over the last several years, a number of studies have pointed toward a causal relationship between solar wind density and the strength of the storm-time ring current. Among other findings, these studies showed 1) a strong correlation between the strength of a given storm (as measured by *Dst*) and the density of the plasma sheet measured at geosynchronous orbit at and just prior to the storm maximum [*Thomsen et al.*, 1998]; and 2) a clear correlation between the maximum storm-time *Dst* and both the solar-wind electric field and the solar-wind density, with separate and independent time lags [*Smith et al.*, 1998]. These results support a scenario in which the intensity of the storm-time ring current is determined by a combination of source strength (plasma-sheet density) and injection strength (interplanetary electric field), with the plasma-sheet source strength ultimately related to the available solar wind density. However, the storms included in these studies occurred near and just after solar minimum and were only moderate in size. The picture may be considerably different for the major storms that are more common during solar maximum, when ionospheric outflow is known to be significantly enhanced. Indeed, recent work by *O'Brien* has found that other intervals during the solar cycle do not apparently display the same correlation between *Dst* and solar wind density found by *Smith et al.* [1999]. In this study, we extend the study of *Thomsen et al.* [1998] to examine the relationship between the ring current and the plasma-sheet density for a set of stronger storms that have accompanied the rise to solar maximum. We further use the very extensive set of geosynchronous plasma measurements to explore more generally the statistical relationship between *Dst* and plasma-sheet density throughout the entire solar cycle.

S8-P01

MAPPING INNER MAGNETOSPHERIC CONVECTION AND INJECTIONS FROM GROUND AND GEOSYNCHRONOUS MEASUREMENTS

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We determine the effects of convection, injections (those of substorms and minor ones), and solar wind compression on the ring current. First we show that $1-2$ hour-period oscillations in either *Dst* or individual magnetometers during storm main phase are linked to strong injections into the ring current. Convection is associated with monotonic changes in high-resolution *Dst* while injections (and their drift echoes) produce oscillations [*Vassiliadis et al., JGR*, 1999]. During the commencement and main phase there are oscillations with periods of $\sim$ 10 min and $\sim$ 1 hour, respectively. Comparisons with LANL geosynchronous data show that the 1-hour oscillations coincide with injection and echo signatures in particle flux.

In LT-UT diagrams [*Clauer and McPherron*, 1974] substorms and convection are seen to develop as two distinct modes of response contributing to the ring current and having separable temporal and spatial features. A similar space-time representation can be constructed from low-energy flux measurements from geosynchronous spacecraft. Filtering methods are used to identify injections and echoes, which can then be localized on the LT-UT diagrams and whose drift speed is calculated. We subtract the transient effects of injections and compression from the magnetograms to produce a corrected disturbance LT-UT profile. The corrected disturbance is due to the trapped particles and can be used to obtain their total energy according to the DPS relation. Further, a principal components analysis (PCA) on the LT-UT profile separates the disturbance into mutually orthogonal modes. We associate the

dominant first PCA mode with convection while higher-order modes appear during injections and drift echoes. In this way we estimate that during the 1991 storm, injections accounted for up to 37 % of the ground magnetic disturbance. Finally by combining the magnetograms with the solar wind electric field input one can produce an empirical predictive model of the geomagnetic disturbance. Nonlinear predictions based on the magnetometer model are significantly more accurate than *Dst* index model predictions.

S8-P02

RELATIONSHIP OF SAR-ARC DYNAMIC CHARACTERISTICS TO THE GEOMAGNETIC ACTIVITY LEVEL

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The statistical analysis of relationship of the SAR arc dynamic parameters to the geomagnetic disturbance level determined by *Kp*, *Dst*, *AL* and *AU* magnetic indices during the 22 nd solar cycle has been carried out. SAR arc photometric observations have been carried out at St. Maimaga, Yakutia (56.5° N; 200° E, geom.). The SAR arc localization latitude and mean velocity of its movement in the equatorial direction in the given temporal sector depend on the current level of the geomagnetic activity. Correlation relationships pointing to the proportional growth of the hourly average values of the SAR arc intensity maximum and velocity of its equatorward movement with increasing of *AL*, *AU* and *Dst* indices have been found. The events of SAR arc registration at low values of *Dst* and *AL* indices are analysed.

S8-P03

GROWTH RATE AND DECAY OF MAGNETOSPHERIC RING CURRENT DURING GREAT MAGNETIC STORMS

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The rate of energy input to the ring current during great magnetic storms is studied as a function of solar wind parameters. The ring current dissipation rate is also examined in connection with the changing of ion composition. Problems of contribution of the magnetopause currents and other current systems to *Dst*-variation are discussed.It is shown that the differences between calculated and observed *Dst* values during great magnetic storms may be accounted for by several explanations, in particular, by incorrect allowance for the contribution of other current systems that can change parameters of ring current models.

S8-P04

COMPARATIVE ANALYSIS OF ION COMPOSITION AND ENERGY SPECTRA OF THE RING CURRENT FOR THE SOLAR ACTIVITY MINIMUM AND MAXIMUM USING GEOSYNCHRONOUS SATELLITE DATA

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Energy spectra of ions with atomic masses from 1 to 16 and the charge state from +1 to +6 (ions from hydrogen to oxygen) in the energy range of 0.1 – 130 keV/e were studied on geosynchronous satellites of the GORIZONT series. Measurements at GORIZONT-21 were made during the solar cycle minimum (1985), and measurements at GORIZONT-35 were made during the solar maximum (1992). Different ion components were found to dominate during geomagnetic storms of various types and power, H^+ and O^+ dominate most often, which proves the important role of the solar source besides the ionospheric source. A number of new dynamic effects, manifesting themselves for ions of the ionospheric and solar origin in different ways, were found. With solar activity growth the ring current is enriched by ionospheric ions and energy spectra of different ion components become similar if they are presented in "energy per charge" units.

S8-P05

STORM-RELATED PLASMA CLOUD INSIDE THE MORNING RING-CURRENT REGION

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Structured sub-keV trapped ion "cloud" with wedge-like energy-latitude dispersion inside or equatorward of low-altitude CPS region is statistically studied using Viking ($H = 2 - 3\ R_E$), Freja (1500 km), and Astrid-2 (1000 km) data. We call this plasma cloud "dayside/deep plasma segment (DPS)" because it is located deep inside the inner magnetosphere (co-located with ring current), and found predominantly in the morning sector. DPS has energy-latitude dispersion in both directions, *i.e.*, from low energy to 1 keV and back to low energy as the satellite travels from low-latitude to high-latitude, but the dispersion form changes for different MLT sectors. DPS is found in almost all satellite traversals, but its intensity varies drastically time to time. The statistics indicates that the DPS enhancement is probably related to magnetic storms or substorms, but the statistics failed to show solid correlation. Therefore, DPS is a kind of ring current but the source is most likely a localized dense low-temperature plasma "cloud" in the nightside. DPS is well understood by particle simulation when the elapse time is taken more than 10 hours. Thus, DPS may provide important source information of the nightside plasma injection many hours before.

S8-P06

SUB-KEV ION PLASMA CLOUD OBSERVATIONS INSIDE THE CPS-REGION DURING MAGNETICALLY QUIET CONDITIONS

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A dense plasma cloud of $0.1 - 1$ keV ions inside the early morning CPS-region in the southern hemisphere was observed by the Astrid-2 satellite on July 3 1999. Computer simulations of the injection and plasma drift show that the plasma-cloud most likely drifted from the night-side during a stormtime substorm injection almost 5 hours before. Therefore, the observed plasma cloud will be a good clue in understanding the substorm phenomena.

S8-P07

STORM-TIME RING CURRENTS AND COSMIC RAYS: DIRECT AND INVERSE PROBLEMS

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DIRECT PROBLEM (influence of storm-time ring current on cosmic ray intensity): This problem is not difficult and was investigated in details during last 50 years. That now the influence of storm-time ring current on cosmic ray cut-off rigidity and trajectories can be determined with good accuracy for different models of storm-time ring current.

INVERSE PROBLEM (determining by observed cosmic ray intensity variations expected properties of storm-time ring current): This problem can not be solved by using only cosmic ray data; it is necessary to use also ground or satellite magnetic data. We show that on the basis of cosmic ray data on several stations by the method of coupling functions and cosmic ray spectrographic method can be determined the change of cut-off rigidity on different latitudes. Obtained information on the changing of cosmic ray cut-off rigidities in combination with ground and/or satellite magnetic data gives possibility to solve the inverse problem and determine parameters of storm-time ring current and their changing in time.

S9-01

SECULAR VARIATION OF HIGH ENERGY PARTICLE FLUXES IN THE SAA REGION

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In the past several decades, the Earth's eccentric dipole moment and its direction have been significantly decreasing and changing, respectively. The structure of the trapped radiation belt at low-altitudes may also have changed in connection with the secular evolution of the geomagnetic field. Some authors pointed out that the low-altitude trapped particle fluxes for beyond the year 2000 would increase dramatically when calculated using standard radiation belt models. Particle flux measurements reported in 1990s tend to support this idea. However, other authors considered that this was not a realistic result. They attributed the error to the inconsistency between the field model epochs used to compute B, L coordinates and those used in constructing the particle flux models. Up to now there seems to be no consensus on this issue yet. Assuming that for long-term variation the sources of particles can approximately balance the sinks and that three particle adiabatic invariants are conserved, we propose the Drift Shell Tracing Method (DSTM) to solve the "inconsistency" problem. By using the DSTM we have made a calculation for the secular variation of high energy particle fluxes in the South Atlantic Anomaly (SAA) region. It is found that during the past three decades the drift shells have considerably descended and deformed and that at the altitudes of 500 km to 1000 km both proton and electron fluxes have significantly increased. Relevant particle flux measurements, theoretical questions and the proper way to apply the standard radiation belt models with the up to date geomagnetic field models are discussed.

S9-02

A LOW ALTITUDE PROTON MODEL DEPENDING ON SOLAR CYCLE PHASE AND SEASON

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The low-altitude trapped proton population exhibits strong time variations related to neutral atmosphere conditions and geomagnetic secular variation. The variation of the solar UV flux over the solar cycle induces a cyclical expansion and contraction of the neutral atmosphere on the same time scale, which in turn drives a cyclical erosion and replenishment of the trapped proton population. Seasonal variations of the neutral atmosphere have a similar, non-negligible effect on a time scale of one year. In addition, the secular variation of the geomagnetic field slowly draws the proton population in the South Atlantic Anomaly region deeper into the atmosphere, resulting in a further gradual change in local radiation conditions. Finally, the strong flux gradients at low altitudes induce an anisotropy in the flux distribution, referred to as the East-West effect.

In order to accurately model the low altitude trapped proton environment, all these effects have to be taken into account. The solar cycle and seasonal effects can be related to the 10.7 cm solar radio flux and the day of year, respectively. The secular variation of the geomagnetic field prohibits the use of McIlwain's (B, L) coordinates over long time scales. Instead, we have used Kaufmann's K and the altitude of the lowest mirror point as map coordinates, as these coordinates are less affected by the secular variation.

We have used several years of proton flux measurements of the Proton/Electron Telescope (PET) onboard the polar satellite SAMPEX to separate the different time scales and to characterise the respective variations. Radiation Environment Monitor (REM) data onboard MIR have been used to quantify the East-West effect.

S9-03

ENERGETIC PARTICLE INJECTION AND SUBSTORM ONSET LOCATION

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Energetic particle flux enhancement events observed by satellites during substorms are studied by considering interaction of particles with Earthward propagating electromagnetic pulses of westward electric field and consistent magnetic field of localized radial and azimuthal extent in a background magnetic field. The energetic particle flux enhancement is mainly due to the betatron acceleration process: particles are swept by the Earthward propagating pulses via the $\boldsymbol{E} \times \boldsymbol{B}$ drift toward the Earth to locations of higher magnetic field and are energized because of magnetic moment conservation. We examine substorm energetic particle injection by computing the particle flux and comparing with geosynchronous satellite observations. From our modeling results of energetic particle flux enhancements which are consistent with those observed by geosynchronous satellites, we find that the bulk of injected energetic particles arrive from distances less than 9 R_E which are closer to the Earth than the values obtained by the previous model of *Li et al.* [1998]. Based on the observations that energetic particle flux enhancement events observed by geosynchronous satellites near midnight location usually occur within $1-3$ minutes after the substorm expansion phase starts, we conclude that the initial location of the pulse which corresponds to the magnetic field dipolarization location during the substorm expansion phase might be at a distance as close as 10 R_E from Earth in the midnight sector.

S9-04

ARE MAGNETIC STORMS QUALITATIVELY DIFFERENT FROM MAGNETOSPHERIC SUBSTORMS?

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The response of the ring current during storms and substorms is investigated using data from the CRRES mission. We selected isolated substorms during magnetically quiet periods, long lasting events of continuous substorm activity (several days) and storm periods. Isolated substorm injections do not contribute significantly to the ring current intensification whereas continuous substorm activity leads to intensification of the outer ring current ($L > 5$). The O^+/H^+ energy density ratio of these substorms is small compared to the corresponding ratio of substorms related to storm periods (recovery phase). During storm time periods a strong dawn dusk electric field convects plasma sheet ions into the inner magnetosphere while during substorms the electric field is much weaker resulting in a smaller convection rate. Therefore our data indicate that Chapman's hypothesis of a storm being equal to the sum of substorms is not valid.

S9-05

RELATION BETWEEN *Dst* AND RELATIVISTIC ELECTRONS DURING MAGNETIC STORMS

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Conventionally Geomagnetic Storms are associated with increases in energetic electrons. We have used Polar and CRRES data to investigate the correlation between Dst and energetic electrons on a number of timescales. On a range of timescales, Dst excursions and the fluxes of energetic electrons actually seem to anticorrelate. This is not simply a question of adiabaticity. It appears that while the onset of a storm can indeed set up the conditions for an enhancement of the electrons, the immediate effect is actually to remove electrons from the system. It is also this effect which finally ends the lifetime of the new belt formed. We investigate the possible role of adiabaticity in reducing measured fluxes. Under this hypothesis, although relativistic electrons are seen immediately following Dst max excursion, the energisation process was going on before, but masked by adiabatic contraction of electron orbits due to the ring current. B_y comparing phase space density of electrons of fixed at different L values, we conclude that this explanation does not appear correct. We also find that the anticorrelation is present on short timescales. B_y performing a superimposed epoch analysis of energetic electrons using substorm onsets to align epochs, we conclude that although obviously substorms produce electrons of "substorm" energies, they do not systematically produce higher energy electrons or change Dst. Phase space density calculations are further employed to address the question of the source of stormtime energetic electrons. We find no evidence of an internal source.

S9-06

DYNAMICS OF OUTER RADIATION BELT ELECTRONS AS OBSERVED WITH THE SAMPEX AND POLAR SPACECRAFT

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Analysis of data from the SAMPEX and POLAR spacecraft shows that energetic electrons ($E > 1$ MeV) vary in a highly coherent way throughout the Earth's entire outer radiation zone ($2.5 < L < 6.5$). Such data have been used to perform long-term analysis of the flux variations of relativistic electrons throughout the outer trapping regions. A large modulation of fluxes is found on time scales of hours to years. It is clear that the near-Earth region responds powerfully to events on the sun and in the solar wind. The Earth's radiation belts and inner magnetosphere show pronounced differences in their characteristics as the interplanetary magnetic field and solar wind speed change. Solar coronal holes produce regular, recurrent solar wind stream interactions in geospace, often enhancing highly relativistic electrons and causing recurrent magnetic storms. These phenomena are most characteristic of the approach to solar minimum. On the other hand, major geomagnetic disturbances associated with aperiodic coronal mass ejections occur most frequently around solar maximum. Observational and modeling results demonstrate differences throughout the inner part of geospace during the course of the 11-year solar cycle. Such features in Earth's radiation belts are a key component and concern of NASA's new "Living With a Star" initiative.

S9-07

FORMATION OF NEW ELECTRON RADIATION BELT DURING MAGNETOSPHERIC COMPRESSION EVENT

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The rapid formation of the new electron radiation belts during March 24 – 28, 1991 magnetic storm was investigated by using Akebono RDM (radiation monitor instrument) observations. Right after the storm sudden commencement (SSC) at 0324 UT on March 24, highly energetic electrons (> 2.5 MeV) were promptly enhanced deep in the inner magnetosphere, forming a new radiation belt peaked around $L = 2.6$. There was very strong magnetic activity around 22 UT on March 24; *e.g.* AE reached 2300 nT and Dst went down to −300 nT, and the new radiation belt moved further toward the Earth with its peak at $L = 2.2$. Measurements from Akebono show that by early March 25 plenty of intermediate-energy (0.3 MeV – 0.95 MeV) electrons were supplied in regions around $L = 2.8$. These electrons could be the source populations, which seeded a subsequent enhancement of highly energetic (> 2.5 MeV) electrons, forming a new radiation belt there. The increase in the intensity of MeV electrons around the peak ($L = 2.8$) was somewhat smooth. It actually took three days (March 25, 26 and 27) for MeV electrons to reach a saturation level. The prolonged substorm activities during the recovery phase of the magnetic storm got these electrons more energetic.

S9-08

TESTING OF RELATIVISTIC ELECTRON ACCELERATION MECHANISMS

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Many theories have been proposed to account for observed changes in relativistic electron fluxes including the "Dst effect" (*Dessler and Karplus*, 1961; *McIlwain* 1966; *Rinaldi et al.*, 1994; *Kim and Chan*, 1997; *Li et al.*, 1999), ULF wave resonance (*Elkington et al.*, 1999; *Hudson et al.*, 1999), VLF wave resonance (*Thorne and Kennel*, 1971; *Summers*, 1998; *Horne and Thorne*, 1998), and simultaneous VLF and ULF wave interaction (*Rostoker et al.*, 1998; *Liu et al.*, 1999).

The "Dst effect" states that fluxes observed at constant energy will track changes in the magnetic field as electrons move to conserve all three invariants. This effect can obscure changes in fluxes due to other interactions but does not affect phase space densities at constant invariants. Using the POLAR HISTe data for Jan 97 – Jun 97, we produce a data set of phase space densities that allows us to see enhancements due to other processes.

We used the 210 meridian magnetometer data in order to investigate the correlation of ULF wave power with relativistic electron phase space densities at four different L values. Many enhancements correlate with ULF wave-power. However, several clear increases in wave power showed no following enhancement of electron phase space density indicating that either another process is responsible for the electron enhancements or that ULF waves alone can not account for the increases.

Here we explore the possibility of VLF wave interaction. We calculate pitch angle distributions using the POLAR HISTe particle data along with the POLAR MFE magnetic field data for the same time period Jan 97 to Jun 97. The pitch angle distributions give an indication of how the particles interact with VLF waves. The orbit of POLAR allows us to describe changes in pitch angle distributions as a function of time and L shell.

S9-09

ELECTRON RADIATION BELT ENHANCEMENTS: CONNECTIONS WITH GEOMAGNETIC ACTIVITY AND SOLAR WIND CONDITIONS

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Twenty-six high speed solar wind stream intervals observed between December 1994 and September 1996 are used to quantify the relationship of equatorial electron flux enhancements occurring near $L = 4.2$ and 6.6 with both geomagnetic activity (Kp) and solar wind conditions. Los Alamos differential-energy electron data from the Synchronous Orbit Particle Analyzer (SOPA), the BDD-II dosimeters aboard GPS Navstar satellites and WIND solar wind velocity, density, and IMF data are utilized. While SOPA ($L = 6.6$) shows post-dropout flux enhancements during these selected events, GPS ($L = 4.2$) detects similar enhancements in $1.6 - 3.2$ MeV electron fluxes only about half the time and all are either concurrent (1 event) with or follow (14 events) the geosynchronous increases of electrons with similar m values. In addition, two-thirds of the observed GPS growth periods result in electron enhancements above the initial pre-dropout levels. A critical factor leading to GPS $L = 4.2$ electron flux enhancements is having geomagnetic activity elevated to levels $Kp \sim 3.0 - 3.5$ and above (conditions associated with large electric field in this region [*Rowland and Wygant*, 1998]). If the inferred outward phase space density gradients are combined with these elevated electric fields, then sufficient conditions may exist to promote inward radial transport of the equatorial electrons arriving at GPS altitudes. The solar wind driving these same growth periods include enhanced values of the solar wind pressure, electric field (with southward IMF), and velocity and are all conditions that affect particle transport throughout the magnetosphere. We report on how both the occurrence and detailed characteristics of the flux enhancement at $L = 4.2$ and 6.6 depend on geomagnetic activity and solar wind conditions.

S9-10

THE DISTRIBUTION OF EXTREME RELATIVISTIC ELECTRON EVENTS AND THEIR SOLAR WIND DRIVERS: SOLAR MAX 1989 TO SOLAR MAX 2000

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Continuous observation of the Earth's trapped relativistic electron populations from the previous solar maximum to the current solar maximum provide a timely opportunity to analyze their behavior over the past 11 years. In this paper we present a phenomenological overview and a statistical analysis of the relativistic electron fluxes measured by Los Alamos energetic particle detectors on geosynchronous satellites ($L = 6.6$) and on the GPS satellites ($L > 4.2$).

In this paper we present an analysis of the fluxes measured at different L-shells and different energies at different phases of the solar cycle. We examine the relationships between the relativistic electron fluxes, geomagnetic activity, and solar wind conditions. In particular we discuss the statistical distribution of fluxes and examine in greater detail the events that lie at the high-flux end of the distribution the extreme relativistic electron events to better understand the geophysical conditions under which they occur.

As well as providing greater physical understanding, a better understanding of the probability of observing certain flux levels under certain geomagnetic conditions is of practical use in designing robust and reliable spacecraft and in developing "climatological" models of the Earth's radiation environment.

S9-11

FULLY-ADIABATIC FLUX CHANGES, SUBSTORM INJECTION, AND RADIAL TRANSPORT OF RELATIVISTIC ELECTRONS

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Although much is known about storm-time variations of outer-belt electrons, the relevant acceleration and transport mechanisms are still not well understood. Much work remains, observationally and theoretically. In this talk results from calculations of fully-adiabatic flux changes, substorm injection, and radial transport of relativistic electrons will be summarized.

Fully-adiabatic changes can successfully account for features of the observed storm-time flux decreases, such as the energy dependence of the decreases and the similarity between *Dst* and the logarithm of the particle flux, but other processes contribute to the decreases and it seems that fully-adiabatic changes typically play a minor role in the observed flux increases.

Injection by substorms and radial transport and energization by ULF waves have been invoked to help explain the flux increases. Simulations show that a small fraction of approximately ten-keV plasma sheet electrons can be substorm injected to an outer trapped region of the magnetosphere; if these particles are further transported to the inner magnetosphere they would have MeV energies. Estimates of the number of electrons which can be injected and transported in this way yields values which are comparable to or somewhat lower than the number observed, suggesting that the substorm injection should be supplemented in order to explain observed flux levels. Calculations of the interaction between ULF waves and relativistic electrons will also be summarized.

S9-12

ACCELERATION PROCESS OF ENERGETIC ELECTRONS IN THE INNER MAGNETOSPHERE DURING MAGNETIC STORMS

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Using the electron data from AKEBONO RDM (300, 950, 2500 keV) and NOAA MEPED (30, 100, 300 keV) measurements, we have investigated the variation of the energetic electron flux, spectrum, and pitch angle distributions in the inner magnetosphere, and discussed the origin of the energetic electron flux enhancement during the storm recovery phase. In the outer radiation belt, the spectrum index of energetic electrons changes from hard to soft during the storm main phase, and changes from soft to hard during the recovery phase. The region where spectrum becomes hard is confined near the plasmapause first, and it propagates from there to the whole region of the outer radiation belt with a significant time delay. The pitch angle distributions of the energetic electrons are enhanced perpendicularly to geomagnetic field in the region of the electron flux enhancement. The activities of LF-band whistler-mode waves observed from AKEBONO PWS measurement are very intense outside the plasmapause during the period. From theses results, we have speculated that the injected hot electrons ($\sim$ 100 keV) from the plasmasheet during the main phase were accelerated by the wave-particle interactions near the plasmapause where the thermal plasma density was very low, and seeded the enhancement of the energetic electrons during the recovery phase. The following possibilities to rebuild the outer radiation belt have been also suggested: (i) the accelerated energetic electrons near the plasmapause have been transported to the whole region of the outer radiation belt by the outward radial diffusion process, (ii) the region of the electron acceleration has expanded towards the whole region of the outer radiation belt.

S9-13

ULF WAVEGUIDE MODES EXCITED BY HIGH SPEED MAGNETOSHEATH FLOWS AND THEIR POSSIBLE ROLE IN ACCELERATING RELATIVISTIC ELECTRONS

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Following geomagnetic storm onsets, decreases in MeV electron fluxes in the main phase are often followed by subsequent flux increases, on the timescale of days, where the flux recovers to exceed pre-storm levels. The flux recovery cannot be explained by the Dst effect alone, and is believed to require the action of a local acceleration mechanism. We present observations from the first half of 1995, during the declining phase of the solar cycle, which show that the recurring trans-equatorial coronal hole fast solar wind streams in this interval produced significant enhancements in both ULF wave power and MeV electron flux in the magnetosphere. Data from GOES7 at geostationary orbit shows that > 2 MeV electron flux is strongly correlated with extended intervals of both large amplitude ULF wave power and fast solar wind speed. The Pc 5 ULF wave power is concentrated in discrete frequency global waveguide modes, and we propose that the several orders of magnitude increase in ULF wave power occurs as a result of the action of a magnetopause Kelvin-Helmholtz instability (KHI). The KHI can strongly energise global waveguide modes under fast solar wind speed conditions, and can hence produce large amplitude electric fields deep in the magnetosphere which are local to geostationary orbit and beyond. A good correlation exists between extended intervals ($3-4$ days) of large amplitude ULF wave power and increases in MeV electron flux at geostationary orbit; the largest ULF wave power events being correlated with the largest MeV electron flux events. This suggests that there is a causal connection between the ULF waves and the increases in MeV electron flux. Hence long-lived intervals of fast solar wind speed might provide a forecasting indicator of a particularly long-lived and harsh MeV electron flux environment at geostationary orbit.

S9-14

SUBSTORM-DEPENDENCE OF CHORUS AMPLITUDES IN THE RADIATION BELTS: IMPLICATIONS FOR THE ACCELERATION OF ELECTRONS TO RELATIVISTIC ENERGIES

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Whistler mode chorus waves are one candidate for electron acceleration to relativistic energies in the Earth's radiation belts. Acceleration can occur by Doppler shifted cyclotron resonance and is more effective when the ratio of the electron plasma to gyro-frequency becomes of the order of unity or less. Here we present a statistical survey of whistler mode chorus amplitudes from the CRRES spacecraft for different levels of magnetic activity as measured by different indexes, Dst, AE, Kp to examine whether the wave acceleration mechanism is supported by enhanced wave amplitudes. Chorus is found to occur primarily outside the plasmapause, but moves to lower L with the plasmapause during periods of increased magnetic activity. The emissions can be divided into lower- and upper- frequency bands that exhibit different latitudinal and local time dependence, and can be further sub-divided into equatorial and high latitude (> 15 degrees) emissions. Equatorial chorus is observed in both bands and is significantly enhanced during active conditions ($AE > 300$ nT) over a range of L-shells, $4 < L < 7$, predominantly in the region 23:00 – 13:00 MLT, consistent with electron injection near midnight and drift around dawn to the day-side. Average lower-band wave amplitudes are typically greater than 0.5 mV/m. High-latitude chorus is observed primarily in the lower- band, but is shifted in local time between 06:00 – 15:00 MLT, consistence with dayside generation in the horns. These emissions are also significantly enhanced during substorms. We show that since chorus amplitudes are strongly enhanced during the main phase of magnetic storms (as measured by Dst) and during substorms (as measured by AE) in the radiation belt region, the data supports the wave acceleration mechanism. However, we note that the

acceleration should also occur outside magnetic storms during periods of strong substorm activity, provided there is a sufficient seed population.

S9-15

EXTREMELY LOW FREQUENCY OSCILLATIONS IN HIGH ENERGY ELECTRON FLUXES AT THE CONCLUSION OF THE MAGNETIC STORM OF APRIL 2000

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A major magnetic storm onset occurred late on the UT day April 6, 2000 with Dst attaining a magnitude of 317 nT. Starting $\sim$ 1600 UT on April 9, GOES 8 began to detect large amplitude oscillations with a period of $\sim$ 0.2 mHz in the $E > 2$ MeV electron flux which lasted until the middle of the following day. During this interval of time, the Geotail satellite in the middle tail region detected oscillations in the plasma sheet at approximately the same period as the electron flux oscillations detected by GOES 8. Unusual low frequency oscillations in the magnetometer and photometer fluxes measured by the CANOPUS array were detected in the evening hours at a frequency considerably higher than that for the electron flux oscillations detected at GOES 8. This paper will document this event of global character and will discuss possible mechanisms for generating such exceptionally low frequency oscillations of the magnetospheric environment.

S9-16

RESONANT SCATTERING OF RELATIVISTIC ELECTRONS

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Relativistic electrons are able to interact with two classes of plasma wave during disturbed conditions in the Earth's magnetosphere. Electromagnetic whistler-mode waves are excited in the pre-midnight to noon sector of the outer magnetosphere following the injection of plasmasheet electrons during substorm activity. These "chorus" emission can propagate to high latitude where they are able to resonantly interact with relativistic electrons. This interaction can cause both stochastic energy diffusion and precipitation loss to the atmosphere. Electromagnetic Ion Cyclotron (EMIC) waves are also generated in the outer magnetosphere by cyclotron resonant interaction with ring current protons. During storm conditions, when the ring current proton population is enhanced, the waves can attain amplitudes above 1 nT. Such waves can resonantly interact with relativistic electrons and this leads to pitch-angle scattering at the strong diffusion rate. The rapid loss of relativistic electrons from the radiation belt during the main phase of a storm could be caused by EMIC waves. The subsequent recovery of relativistic electron fluxes during the recover phase of a storm requires a rapid energization process, stronger than the anticipated losses due to pitch-angle scattering. Energy diffusion by enhaced levels of chorus waves could contribute to this acceleration.

S9-17

INVESTIGATION OF RELATIVISTIC ELECTRON DYNAMICS USING LINEAR FILTER PREDICTION TECHNIQUES

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Relativistic electron flux levels at geostationary orbit vary strongly over time scales ranging from minutes to several days. As is known from prior research, the acceleration processes that create the energetic electrons occur within the magnetosphere, while the basic energy source for the acceleration appears to be the solar wind flow. In this paper we evaluate the extent to which the electron flux at geostationary orbit can be predicted using a linear prediction filter technique driven by solar wind speed alone, and we investigate additional factors that may also affect the electron flux levels. A model has been developed by *C. Smithtro* to predict the daily fluence of relativistic electrons in the magnetosphere at geostationary orbit based on measured or predicted solar wind speed. This model is derived from the linear prediction filter technique developed by *Baker et al.*, *JGR*, 1990. The model is used routinely at the NOAA Space Environment Center to make predictions with one, two, and three days of lead time. In addition to the basic linear prediction filter technique, this model also employs a flux offset that adjusts the predicted flux based on the accuracy of the previous prediction. This offset improves the predictions considerably, and is used to quantify variations in the response of the magnetospheric electrons to the solar wind conditions.

S9-18

DYNAMICS OF ENERGETIC PARTICLES IN THE INNER RADIATION BELT DURING MAGNETIC STORMS

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The relation between energetic particles in the inner radiation belt and magnetic storms is investigated using the NOAA12 and Akebono satellite data. During the main phase of a magnetic storm, the proton flux enhancement in the energy range from 30 – 80 keV is detected in the inner region of the radiation belt as has been first reported by *Frank* (1967). The present analysis disclosed that the proton enhancement occurs almost simultaneously deep in the inner belt, and its lower boundary is less than $L = 2$. The time profile of the proton flux variation is quit similar to that of Dst. These suggest that the ring current protons are accelerated not only in the outer region but also in the inner region of the radiation belt. We suppose that the induced electric field by the ring current variation should be the cause of the proton acceleration in the inner region. Electron spikes in the energy range from 30 to 300 keV are also detected in the inner radiation belt during the main phase of the magnetic storm. The flux increases up to 10 times with the duration of less than 1 day. This impulsive enhancement (electron spike) is synchronized with the onset of the outer belt electron decrease, but not related with the transport or injection process from the outer belt,indicating the existence of the independent acceleration process.

S9-19

ON THE RELATIVISTIC ELECTRON SOURCES DURING MAGNETIC STORMS: ANALYSIS WITH THE SALAMMBO CODE AND COMPARISON TO IN-SITU DATA

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There are several candidates that have been put forward to explain the observed relativistic flux profiles observed after storms, mainly based on geosynchronous observations. While some features during some storms are consistent with each of the mechanisms put forward (acceleration by ULF waves, substorms, recirculation at the plasmapause and simple diffusion from an enhanced source), this has not lead to a consistent paradigm that can be applied to the existing large variety of observed storms – which has lead to the infamous phrase "If you've seen one storm – you've seen one storm".

In this paper we will attempt to explain a wide range of very different storms with a single paradigm – one that is based on the physical building blocks of the Salammbo Diffusion Code. These blocks are fairly simple: A measured boundary condition, activity dependent diffusion coefficients and an internal acceleration mechanism tied to wave activity at the plasmapause. Many of these building blocks are parameterized by Kp to the first order. We will present simple arguments based on the time history of the Kp-index and these building blocks that enable us to predict the general behavior of the relativistic electrons for a given storm, globally throughout the inner magnetosphere. We will then test these predictions against the GPS observations of the relativistic electrons in the $L = 4$ to 8 range.

S9-20

THE ENERGETIC ELECTRON AND ION RESPONSE TO THE GEM MAGNETIC STORMS: HEO AND POLAR SATELLITE OBSERVATIONS

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We combine the energetic electron and ring current ion observations from Polar and HEO (94-026, 95-034, and 97-068) to study the magnetosphere response to the GEM Inner Magnetosphere Campaign Storms of May 2 – 4, August 26, September 25 and October 19, 1998. The electron observations are taken by high-altitude high-inclination satellites at energies > 100 keV while the ions are > 10 keV/q from Polar and protons > 80 keV from the HEO satellites. The HEO (94-026, 95-034, and 97-068) satellites are in $\sim$ 12 hour orbits at different local times while Polar is in an 18 hour orbit. The HEO coverage occurs roughly in the pre-noon/pre-midnight, post-noon/post-midnight and dawn/ dusk regions of the inner magnetosphere. Polar covers the pre-noon/pre-midnight region. HEO 94-026 and 95-034 provide coverage generally for $L \sim 4$ while HEO 97-068 covers $L \sim 2$ and Polar covers $L \sim 3$. These data are combined to provide a picture of the evolution of the energetic electrons and ring current ions with time, local time, L, and energy for the GEM storms. These combined observations will be presented and discussed in terms of the development of the storm from the electron and ion perspective from low to mid latitudes. We will discuss the generation of relativistic electron enhancements in the inner magnetosphere in terms of the solar wind conditions. We will show evidence that the storm time energetic electron angular distributions are nearly isotropic. We will also show examples of the electron phase space densities and discuss the limitations of such analyses imposed by current magnetic field models. Finally, we will use the combined ion data to show the evolution in local time of the ring current ion radial profiles during the storms.

S9-21

GLOBAL COHERENCE OF RELATIVISTIC ELECTRON ENHANCEMENT EVENTS: MULTI-SATELLITE MEASUREMENTS DURING THE SOLAR CYCLE NUMBER 23

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There have been several significant geomagnetic events during this current solar cycle period (solar cycle number 23) including major magnetic storms and a period of unusually low solar wind speed. We examine the magnetospheric response to these events focussing on the relativistic electron population in the outer zone. In particular, we will use observation from multiple satellites to investigate the global nature of relativistic electron enhancements. Past observations have suggested that relativistic electrons behave in a very coherent manner across L-shells, pitch angles and altitudes. We will compare the relativistic electron fluxes measured by SAMPEX, Polar, HEO and geosynchronous satellites. The association of inner belt proton enhancements with the electron enhancements will also be investigated. The low earth orbit of SAMPEX and the high altitude ($2 - 9\ R_E$) Polar orbit together with measurements at the geostationary orbit ensure very broad L-shell, pitch angle and spatial coverage of relativistic electrons. Continuous monitoring of the interplanetary conditions is provided by sensors on ACE and WIND. A demonstration of global coherence would provide important constraints for the various proposed mechanisms for electron energization in the earth's magnetosphere.

S9-P01

THE DYNAMIC ENERGETIC RADIATION TRACKER (DILBERT): A NEW 3D DIFFUSION CODE

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Particle transport in the inner magnetosphere is often described in terms of the breaking of one or more of the three adiabatic invariants of single particle motion. Radial diffusion, wave-particle scattering and heating, Coulomb collisions, and charge exchange, along with sources and sinks, can be responsible for global evolution of particle distributions. Another class of processes, typified by rapid injection driven by $\boldsymbol{E} \times \boldsymbol{B}$ convection, is more strongly nonadiabatic. In recent years, "radial diffusion" simulations in 3D by the Salammbo code have usefully extended more classical 1D and 2D efforts. This code models the magnetosphere as a tilted, offset dipole, which has the benefit of making the translation between physical and adiabatic variables trivial, at the expense of realism, especially during magnetically disturbed periods. A new code, under development, makes the correspondence between sets of variables by tracing drift shells computationally, with an arbitrary choice of magnetic field model. This code, the Dynamic Energetic Radiation Tracker [D(I,L,B) ERT or DILBERT], also evaluates and drift-shell averages the transport coefficients appropriately, for use in a 3D diffusion simulation. This presentation will describe the physical issues, their practical computational implementation, and early results of this approach to the large scale simulation of trapped particle dynamics.

S9-P02

ENERGETIC ELECTRON RESPONSE DURING THE GEOMAGNETIC STORM OF SEPTEMBER 24 – 26, 1998

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The geomagnetic storm of September 24 – 26 was characterized by high solar wind speeds (> 800 km/s) and an order-of-magnitude increase in outer zone electron fluxes occurring over a period of less than 18 hours. A shock seen at the leading edge of the region of high solar wind speeds induced a storm sudden commencement that may have lead to a limited injection and energization of electrons; however, the time scale over which the bulk of the acceleration appears to have taken place suggests another acceleration mechanism may have been active during this event. MHD/particle simulations of the relativistic electrons during this event were undertaken, and show good correspondence to both geosynchronous observations and measurements made by the POLAR spacecraft. Comparison of these simulations to those using a simple analytic field model composed of a non-axisymmetric dipole field and superimposed ULF oscillations suggest that the observed electron enhancement may have been the result of a drift-resonant interaction with Pc 5 ULF waves. The results of each of these simulations will be presented, and comparison with in-situ measurements will be made to show the extent to which the observed electron enhancement may be attibuted to such a drift-resonant acceleration process.

S9-P03

FLUX ENHANCEMENT OF ENERGETIC PARTICLES IN THE NEAR-EARTH REGION: GEOTAIL-HEP OBSERVATION

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Flux enhancements of energetic (> 80 keV) ions in the Earth's magnetosphere were studied using the energetic particle data obtained by the HEP-LD instrument onboard the GEOTAIL spacecraft. Sudden increases in energetic particle fluxes observed in the magnetosphere can be classified into events with clear energy dispersions (dispersed events), and those without energy dispersions (dispersionless events) where fluxes of energetic particles with different energies are enhanced simultaneously. We visually inspected the HEP data during Jan. 1996 – May 1998 and then identified 56 ion dispersed events and 85 ion dispersionless events. We analyzed spatial distributions of those events in the magnetosphere. It was found that the dispersed events are distributed preferentially on the dusk side in the near-tail plasma sheet ($-30\ R_E < X < -12\ R_E$), while are found at all local time sectors in the near-Earth region ($R < 12\ R_E$). Examining the local time dependence in detail, we found that the dispersed events are relatively rare at the noon and midnight sectors as compared to the dawn and dusk sectors. On the other hand, the dispersionless events can be found only on the nightside, never found on the dayside. Contrary to the dispersed events, Its occurrence rate has a peak around local midnight and decreases rapidly away from the midnight to both dawn and dusk. This result indicates that the source of the energetic ions is located around the midnight sector in the near-Earth plasma sheet. We also investigated the correlation of dispersionless flux enhancements with substorm activities. It was found that most of the dispersionless events are associated with substorm activities determined from magnetograms on ground stations. To examine a detail timing difference between dispersionless flux enhancements in the plasma sheet and substorm onsets, we compared start times of the flux enhancements with Pi 2 onset times corresponding to the substorms. The result is that most of the dispersionless flux enhancements occur within ± 5 minutes from Pi 2 onsets, and the average value of time delay is +3.6 minutes (that is, flux enhancements occur 3.6 minutes after substorm onsets on average). There exists several events preceding the corresponding substorm onsets, while a few events delayed more than 10 minutes from substorm onsets.

S9-P04

ACCELERATION OF OXYGEN IONS OF IONOSPHERIC ORIGIN IN THE NEAR-EARTH MAGNETOTAIL DURING SUBSTORMS

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Measurements from the suprathermal ion composition spectrometer (STICS) sensor of the energetic particle and ion composition (EPIC) instrument on the Geotail spacecraft were used to investigate dynamics of O^+ ions of ionospheric origin at energies of 9 keV to 210 keV in the near-Earth plasma sheet during the substorm expansion phase. Substorm signatures were clearly observed on the ground at 1850 UT on May 17, 1995. In the expansion phase of this substorm, Geotail stayed in the plasma sheet at $X \sim -10.5\ R_E$ and observed a local dipolarization signature accompanied by strong disturbances of the magnetic field. From the energetic ion flux data of EPIC/STICS, we obtained the following results: (1) energetic flux enhancement was more pronounced for O^+ than for H^+; (2) the flux was enhanced almost simultaneously with local dipolarization; (3) the enhancement factor of O^+ ions, which represents the enhancement of the O^+ flux ratio (after and before substorm onset) relative to the H^+ flux ratio, was as large as 1.31; and (4) thermal energy increased from 8.9 keV to 42.8 keV for O^+ ions and from 9.4 keV to 15.9 keV for H^+ ions. These results suggest that O^+ ions are commonly more energized than H^+ ions during the substorm expansion phase. To interpret these observational results, we propose a mechanism in which ions are accelerated in a non-adiabatic way during substorm-associated field reconfiguration.

S9-P05

EMPIRICAL RECONSTRUCTION AND ANALYSIS OF OUTER ZONE ENERGETIC ELECTRON SPECTRA AT ALL LOCAL TIMES

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The storm-related enhancement of energetic electron fluxes in the outer radiation belt is an outstanding problem in both the magnetospheric physics community and the operational space weather community. A key to understanding this phenomenon is the separation of spatial and temporal variations from measurements made by slowly orbiting spacecraft. We have developed a Probabilistic Energetic Electron Reconstruction (PEER) technique which produces very high quality maps of electron fluxes at several energies throughout the outer zone based only on measurements from as few as one spacecraft. The underlying approximation in this model is that measurements at different locations can be related by an arbitrary one-to-one function. We have focused on the time series of fluxes that would have been observed by a stationary spacecraft located at local noon in geosynchronous and GPS orbit. We have used the reconstructed noon fluxes in a superposed epoch analysis to assess potential interplanetary and magnetospheric precursors to enhancement of the electron population. We also describe the storm-related development of the spatial and energy structure of the outer belts.

S9-P06

GLOBAL ULF WAVE ACTIVITY DURING THE MAY 15, 1997 MAGNETIC STORM

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Intriguing idea nowadays widely discussed is that the acceleration of relativistic electrons during strong magnetic storms might be related to ULF waves in the Pc 5 band. Several mechanisms of the electron acceleration by long-period ULF waves have been suggested recently. Therefore, the features of storm-related ULF activity as a possible "driver" for the relativistic electron acceleration are to be well known. We study the behavior of ULF activity in the Pc 5-6 band on a global scale during the intense magnetic storm on May 15, 1997, using data from stations in the INTERMAGNET, Greenland Coast Array, IMAGE, and CPMN (210 MM) networks. Two regions of long-period broad-band ULF intensification are observed during the magnetic storm: one is in early morning hours, the other is near dusk. The first one is, probably, related to the energetic electron injection, whereas the other one is due to the injection of ring current protons. It is suggested that ULF waves may be an intermediate agent transferring energy from the ring current protons to the relativistic electrons. The features of the observed broad-band ULF oscillations impose some constrains on models of relativistic electron acceleration by MHD waves during magnetic storms.

S9-P07

ENERGY SPECTRA OF THE PLASMA SHEET AND RING CURRENT IONS: INTERBALL TAIL PROBE OBSERVATIONS

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The solution of the Space Weather problems requires the investigation of the distribution function formation and evolution in the magnitospere in a wide interval energies and pitch angles. The observations on satellite INTERBALL Tail Probe provide the determination of the energy spectra in the wide energy range from 10 eV to 3 MeV. The problems of CORALL, DOK-2 and SKA-2 instruments intercalibration are discussed. The spectra of particle energy are analyzed at different geomagnetic conditions. In most cases the spectra have rather smooth form without any features consisting of the plasma sheet and ring current particles. The processes of particle acceleration and stichastization are discussed. As the acceleration of the magnitosperic particles in many cases has impulsive character, the powerful processes of stochastization must act to form observed smooth distribution function.

S9-P08

INNER RADIATION BELT OF POSITRONS ORIGINATED IN NUCLEAR REACTIONS ON RAREFIED ATMOSPHERES

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The ratio of positron/electron fluxes originated in nuclear spallation reactions in the Earth's magnetosphere is considered. It is supposed that positrons as well as electrons are produced in the decay of charged pions born in nuclear collisions of trapped relativistic inner zone protons with the residual atmosphere. These positrons and electrons are captured in magnetosphere and create positron and electron radiation belt of nuclear origin. The positron/electron trapped magnetosphere fluxes formed with this mechanism from radiation belt proton source are simulated and resulting computed e^+/e^- flux ratio ~4 appears in agreement with the recent observations made by Alpha Magnetic Spectrometer (AMS) (*Cern Courier*, 1999). There > 200 MeV positron flux with the intensity about 4 times higher than the electron flux of the same energy was registered in the equatorial region at the altitude of ~400 km. This ratio is significantly different from the computed ratio ~1 obtained from the primary cosmic ray source through the same mechanism.

S9-P09

TO WHAT EXTENT DYNAMICS OF EXTERNAL RADIATION BELT ELECTRON FLUXES DEPENDS ON THE PRE-HISTORY OF GEOMAGNETIC ACTIVITY

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Empirical dynamic models of the outer radiation belt developed today use standard geomagnetic indices (*AE*, *Kp* and *Dst*) as input parameters. At the same time the relation of dynamics of these indices with that of particle fluxes, measured on geostationary orbit, is not investigated in detail like the forecasting ability of indices mentioned. The work is devoted to research of correlation coefficients between three-hour values of electron fluxes measured on geostationary spacecraft 1977-007 (October 1977 – December 1978; 6 energy bands from 30 keV to 1360 keV) and indices of magnetic activity – *PC*, *AE*, *Kp* and *Dst*, smoothed by moving average with different window width (from 1 day to 10 days).

It was found out that the optimum width of moving average window exists for smoothing of geomagnetic activity indices, at which the correlation coefficient is maximal and exceeds one received for unsmoothed fluxes and indices (or for fluxes and indices, smoothed by identical windows). This optimum width of moving average window is identical for all magnetic indices, but depends on the energy of electrons being in range from 2 till 5 days.

The time lag between smoothed indices and measured electron fluxes determines forecasting ability of indices considered. This time lag increases with electron energy, reaching 70 – 80 hours for energies 930 – 1360 keV. Results received are interpreted in terms of acceleration processes and their localisation in the magnetosphere.

S9-P10

ENERGETIC ELECTRON PRECIPITATION FROM INNER MAGNETOSPHERE AND DIAGNOSTICS OF THE COLD PLASMA DISTRIBUTION IN THE EQUATORIAL PLANE

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Localised electron precipitation associated with a sharp increase of the trapped flux of energetic electrons is observed by low-altitude satellites in the evening sector at the recovery phase of geomagnetic storm. We suggest that this precipitation is the result of cyclotron instability of the ring current energetic electrons at the boundary of the cold plasmaspheric plasma detached from plasmasphere. To verify this suggestion we combined the energetic electron observations from the low-altitude polar orbiting NOAA satellites with observations of cold plasmaspheric plasma onboard geosynchronous spacecraft. Mapping of the electron precipitation peculiarity onto equatorial plane showed a good co-location of the precipitation and western boundary of the detached cold plasma. Moreover, we found clear dependence of the "diffusion parameter" (that is a ratio of precipitating and locally trapped fluxes) on the cold plasma density. The parameter characterises the intensity of pitch-angle scattering. The obtained dependence is in a good agreement with a prediction of the model of cyclotron interaction of energetic electrons and whistler waves developed by *Pasmanik et al.*, (*Ann. Geophys.*, **16**, 322, 1998). We conclude that low-altitude observations of energetic electron precipitation can be used for diagnostics of the cold plasma distribution in the equatorial plane.

S10-01

MAGNETIC RECONNECTION – INTRODUCTORY LECTURE

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The process of magnetic field line reconnection is generally recognized as an essential element both in explosive energy releases (solar flares, magnetospheric substorms) and in formation of complex magnetic topologies (open magnetospheres). It presupposes on global scales the existence of complicated magnetic structures of particular types and on local scales definite departures from ideal MHD. I will review the basic concepts and the major open questions, with attention to relative role of global and local aspects, effects responsible for non-MHD behavior, and what should be addressed by computer simulations.

S10-02

NEW RESULTS OF MHD SIMULATIONS OF SUBSTORM MAGNETOTAIL DYNAMICS

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Theory, computer simulations, and observations have demonstrated the important role of microscopic processes in the magnetotail in the initiation of substorms, presumably closely associated with a late growth phase current intensification or thin current sheet formation. However, the underlying field configuration may also have a significant influence on the stability of the tail, even when a dissipation mechanism is available. We discuss properties of the tail that might affect the stability or the dynamic evolution, based on recent large-scale MHD simulations of magnetic reconnection in the magnetotail.

S10-03

RECONNECTION IN THE EATH'S MAGNETOTAIL: RECENT OBSERVATIONS AND FUTURE OPPORTUNITIES

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Recent observations of reconnection in the Earth's magnetotail and its effects are reviewed. Measurements relating to the nature of reconnection at both the "near-earth" and "distant" neutral lines will be examined. In addition, some comparisons will be presented between the predictions of theory and simulation and the observed signatures of tail reconnection. Finally, the future opportunities for new observations of reconnection offered by NASA's Magnetospheric Multiscale and Magnetospheric Constellation Solar Terrestrial Probe missions will be briefly described.

S10-04

MAGNETIC FIELD LINE TOPOLOGY OF THE EARTH'S MAGNETOSPHERE: RESULTS OF GLOBAL SIMULATIONS

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Topology of magnetic field lines in the earth's magnetosphere must be one of the most important factors to inflow and outflow of the plasma and energy between the solar wind and the magnetosphere. The topology is determined by magnetic reconnection between the interplanetary magnetic field (IMF) and the geomagnetic field lines at the magnetopause and also in the magnetotail. The important factors to magnetic reconnection are where it occurs in the magnetosphere and how the field lines in association with reconnection move. Movement of field lines, namely magnetospheric convection originates from small imbalance of force in the magnetosphere. Topology of magnetic field lines in the earth's magnetosphere has been studied on basis of 3-dimensional global MHD simulation of interaction between the solar wind and the magnetosphere. Topology is basically determined by magnetic reconnection and associated magnetospheric convection. Magnetic reconnection favorably occurs in antiparallel field region with a slower velocity near the magnetopause. A almost closed magnetosphere is formed for a pure northward IMF. When the IMF has finite y-component as well as z-component, open field region exists. Configuration of field lines in the magnetosphere much differs from the superimposed model of geomagnetic field and a uniform IMF. This is because magnetospheric configuration is formed as a result of nonlinear processes. When an outer portion of reconnected field lines propagates downward with the solar wind, another portion of the field lines in the magnetosphere slips along the magnetopause and drives a torque force to the magnetotail. Topology changes in transient phenomena as well as in steady states are also discussed from global MHD simulations.

S10-05

THEORY OF COLLISIONLESS RECONNECTION: EFFECTS OF HALL CURRENT AND ELECTRON PRESSURE GRADIENT

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Analytical and numerical results are presented on two-dimensional, quasi-steady collisionless reconnection on the basis of the generalized Ohm's law, including the effects of the Hall current and electron pressure gradient. The dispersion relations of the waves in the ideal as well as the reconnection region are discussed, including the effects of plasmas β and spatial inhomogeneities of the background magnetic field. In the absence (presence) of the guide field, the reconnection layer supports obliquely propagating Alfvén-whistler (kinetic Alfvén) waves. Analytical estimates are given for the reconnection rate, and a recent claim by Shay and co-workers that the reconnection rate is a "universal constant" is questioned. Although the leading order reconnection rate is independent of the mechanism that breaks fields-lines (resistivity or electron inertia) and the system size as the system size becomes large, it does depend on global conditions such as the boundary conditions driving reconnection. The analytical predictions are tested by Hall MHD simulations. Salient features of the theoretical model and simulations are compared with recent observations from POLAR.

S10-06

COMPARISON BETWEEN THE MAGNETOTAIL VARIATIONS DURING SUBSTORMS OBTAINED FROM GEOTAIL DATA AND THOSE OBTAINED BY ELECTROMAGNETIC HYBRID SIMULATIONS

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A multi-dimensional superposed epoch analysis of plasma and magnetic field data from the GEOTAIL spacecraft was used to visualize the time evolution of the Earth's magnetotail associated with substorms. The substorm events were identified by Pi 2 events at mid-latitude ground stations when the GEOTAIL was in the downtail region from $-10\ R_E$ to $-200\ R_E$. Plasma density, velocity, temperature, and magnetic field data were sorted and analyzed according to the Pi 2 onset time. We found that plasma acceleration does not take place in a small region around $X \sim -20\ R_E$, but occurs in more widely spread region extending from $X \sim -20\ R_E$ down to $X \sim -90\ R_E$. The spatial structure of the plasmoid is characterized by a bi-latitudinal structure where the fast plasma flow in the plasma sheet boundary stretches from the equator and a relatively slow plasma sheet flow is encountered with pre-existing plasma sheet populations. Finite B_y fields are created in the inner plasma sheet boundary, and the total pressure is enhanced inside the plasmoid. By comparing our results with those from the electromagnetic hybrid simulations of the magnetic reconnection, we found that the evolution of the plasma and magnetic fields as well as other parameters, such as the number flux of plasma or energy fluxes, agreed well with the simulation results.

S10-07

EVIDENCE FOR RECONNECTION AND ASSOCIATED HALL EFFECTS IN THE MAGNETOTAIL: WIND OBSERVATIONS

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We present WIND observations of a high speed flow event lasting more than 10 hours with flow speeds reaching 800 km/s in the plasma sheet at $X_{gse} \sim -60R_E$. The results of the shear-stress balance test (the Walen test) indicate that the flow in the deHoffmann-Teller frame has an average flow speed that is 60 % of the Alfvén speed, consistent with the presence of slow shocks in the magnetotail reconnection layer. Furthermore, the slope of the Walen regression line switches sign at the flow reversals, as expected from reconnection. Consistent with the passage of a reconnection X-line, the magnetic field component normal to the neutral sheet also reverses sign at the flow reversals. Around the flow reversal we observe a bipolar By signature consistent with Hall currents expected in the ion diffusion region, implying that WIND encountered the reconnection diffusion region.

S10-08

SUPRATHERMAL ELECTRONS IN MAGNETIC RECONNECTION

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The Geotail satellite sometimes observes the hot electrons of several keV with the non-thermal high-energy population above 20 keV. During the last decade the existence of energetic electrons in association with the magnetotail activity has been studied in the earth's magnetotail. We study the origin of the energetic electrons in terms of collisionless magnetic reconnection by using both the Geotail data and the particle-in-cell simulation. We find that the non-thermal high-energy electrons can be found around the boundary between the plasma sheet and the lobe. On the basis of our simulation results, we propose a simple stochastic acceleration model to produce the non-thermal electrons by reconnection.

S10-09

KINETIC SIMULATIONS OF RECONNECTION AND MAGNETOSPHERIC DISRUPTIONS

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Substorms in the terrestrial magnetosphere and solar flares exhibit a certain commonality in that the magnetic energy accumulates on a relatively long time scale and is then released suddenly or explosively on nearly the Alfvén time scale. This dual character of directly driven versus explosive indicates that the understanding of reconnection must be pursued at two levels: (1) the detailed microphysics which breaks the frozen-in condition and (2) the effects of the boundary conditions which the large scale system imposes on the reconnection region. These twin issues are addressed via large scale 3-D particle-in-cell simulations. The GEM magnetic reconnection study of microphysics is generalized to 3-D by localizing the perturbation of the Harris equilibrium which produces a X-type neutral line to a finite width in the direction of the equilibrium current and by allowing plasma to flow out of the simulation system along the reconnection layer. The global issues are investigated through a study of convection in the plasma sheet. A tailward gradient in the equatorial magnetic field drives an interchange (plasma bubble) instability which launches a localized plasma jet earthward. The diversion of this flow in the near-Earth region produces a region 2 sense field-aligned current, while the primary flow produces a current to the ionosphere whose signature is consistent with the auroral streamers. A convection field localized near midnight can induce reconnection in a limited y region. Sudden removal of this field can produce a region 1 sense diversion of the current.

S10-10

KINETICS OF THREE-DIMENSIONAL MAGNETIC RECONNECTION

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Three-dimensional magnetic reconnection is the generic consequence of the decay of thin current sheets (TCS) which form inside and at the boundaries of magnetized space plasmas as a consequence of the application of external forces. Since the thickness of TCS compares with the characteristic particle scales the investigation of reconnection through them has to be carried out kinetically. We present new theoretical results and particle code simulations of three-dimensional kinetic reconnection. In particular we consider the influence of external fields and the helicity evolution.

S10-11

PARTICLE-IN-CELL SIMULATIONS OF THREE-DIMENSIONAL MAGNETIC RECONNECTION

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Magnetic reconnection is a fundamental transport mechanism in collisionless plasmas, such as frequently found in space. Despite this obvious importance, the nature of the dissipation mechanism underlying the reconnection process remained a mystery until recently. During the last few years, 2.5 dimensional particle-in-cell (PIC) simulations have shown that the electric field in the central, electron, section of the dissipation region is balanced by electron thermal inertial effects. Macroscopically, these effects manifest themselves in a non-gyrotropic electron pressure tensor. While this evidence appears compelling, the question remains whether this dissipation process prevails in three dimensions, where modes with wave vectors parallel to the current density are permitted also. In order to shed light on this question, we present results of 3D PIC simulations of a reconnecting current sheet. Specific emphasis will be on a comparison with two-dimensional model results. We will also discuss the role of a current-aligned magnetic field component.

S10-12

SIMULATION STUDIES OF VORTEX-INDUCED MAGNETIC RECONNECTION IN A COMPRESSIBLE PLASMA

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Vortex-induced magnetic reconnection model (VIR) was proposed and extensively investigated in the past on the bases of two-dimensional MHD simulation in incompressible plasmas. It seems that at the present time the generation condition and main properties of VIR in compressible plasmas have not been clearly understood yet. The present paper summaries recent progresses in these aspects, along with a few new study considering somewhat more realistic conditions at the dayside magnetopause. Simulations show that: (1) In compressible plasmas VIR occurs when the characteristic field-aligned Alfvén (CFAA) number is larger than a lower critical value M_c and less than an upper critical value M_u. M_c is found to be about 0.1 and M_u corresponds to the case that the magnetosheath flow approaches to the phase velocity of the magnetosonic wave. (2) If both sheared low and local resistivity enhancement exist in the reversed magnetic field, the bursty single X-line reconnection (SXLR) and VIR appear, respectively, in the case when the CFAA number is less and larger than M_c. An SXLR-type field and flow pattern gradually changes into the VIR-type if the CFAA number substantially increases. (3) The global reconnection configuration at the dayside magnetopause illustrates that the VIR-type magnetic islands and flow vortices are formed away from the equator, moving toward the high latitudes. (4) Further studies with $2+\frac{1}{2}$-dimensional simulation indicate that the basic features of VIR are not changed when the Hall effect is taken into account.

S10-13

RECONNECTION WITHOUT INSTABILITY

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In the context of investigating the transfers through the magnetopause boundary, the causes for reconnection are revisited. Only two scenarios are generally considered in the literature: 1) quasi-stationary reconnection and most often: 2) growing reconnection due to a local instability (tearing). It is even a common use to claim that there is no reconnection when it can only be proved that there is no reconnecting instability. In both cases, a simple geometry with X points is generally supposed. We will present a different study where the magnetopause is a stable tangential discontinuity but where transfers can nevertheless occur due to reconnection. The original cause that we invoke is the existence of a magnetic turbulence convecting from the shock region and impinging the magnetopause. This turbulence is converted onto the Alfvén mode in the boundary gradient, where it is trapped and amplified. There, we show that it can allow for transfers through the boundary, for both the magnetic flux and the plasma. A non ideal effect is of course mandatory for allowing such transfers: our model is calculated in the frame of Hall MHD, which means that the ion inertia effects are taken into account in the Ohm's law. The finite Larmor radius effects are not presently taken into account. Furthermore, we show that the magnetic flux reconnected per second through a perpendicular elementary surface can be calculated as a function of the local parameters; we are thus able to propose the definition of a local reconnection rate Analyzing the numerical results corresponding to the propagation of a linear Hall-MHD wave through the magnetopause, we estimate this reconnection rate and show that the reconnection is localized near the maximum of the trapped Alfvén wave.

S10-14

OBSERVATIONS OF LARGE SCALE MAGNETIC RECONNECTION AT THE DAYSIDE MAGNETOPAUSE

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We present evidence for large-scale reconnection at the dayside magnetopause based on simultaneous dual-spacecraft detection of reconnection flows. In one event, Equator-S and Geotail detected bi-directional reconnection jets at the dawn flank magnetopause under stable southward interplanetary magnetic field (IMF) condition. SuperDARN radar data further reveals the presence of poleward plasma flows across the polar cap boundary extending from 8 to 15 MLT, consistent with the presence of an extended equatorial X-line spanning the entire dayside magnetopause from dawn to dusk. In another event, Geotail and Wind simultaneously detected reconnection flows near the subsolar point and at the dawn flank magnetopause, respectively. This event occurred under large and stable IMF B_y condition. The deduced reconnection sites are consistent with the X-line being controlled by the IMF orientation. Our observations thus suggest that under steady IMF conditions reconnection is large scale, not patchy.

S10-15

SOLAR FLARES AND MAGNETIC RECONNECTION PROCESSES

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A model describing physical processes of solar flares is proposed based on resistive MHD simulations of magnetic arcade evolution. The individual flaring process encompasses magnetic reconnection of arcade field, generation of magnetic islands, and coalescence of magnetic islands. When the magnetic shear of the arcade field is increased over a threshold (via footpoint motion or flux emergence or both), a current sheet is formed and magnetic reconnection takes place to form a magnetic island. In the underlying arcade below the magnetic island, a new reconnection process can be triggered by a continuing increase of magnetic shear to create a new island. The newborn island rises faster than the preceding island and merges with it to form one island. Before the island merging process is completed, the newborn island exhibits two different phases of rising motion: the first phase with a slower rising speed and the second phase with a faster rising speed. This is consistent with the Yohkoh observation of the upward motion of X-ray plasma ejecta by *Ohyama and Shibata* [1998]. The first phase, in which reconnection of line-tied fields in the underlying arcade is important, is considered to be the preflare phase. In the second phase, the island coalescence process creates an elongated current sheet in the underlying arcade and enhances the reconnection of line-tied arcade fields. This phase is considered as the impulsive phase or the flash phase of flares. The reconnection electric field during the second phase is large enough to accelerate electrons to an energy level greater than 10 keV necessary for hard X-ray production. After the island merging is completed, magnetic reconnection continues in the current sheet under the integrated island for a longer period which is considered as the main phase of flares. The sequence of all these processes is repeated with some time interval while the magnetic shear is increased.

S10-16

COLLISIONLESS TEARING INSTABILITY AS A SUBSTORM TRIGGER AND ITS RELATION TO THIN CURRENT SHEETS

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The role of collisionless tearing instability as a trigger for substorm expansion phase onset is a subject of continuing debate. Spontaneous reconnection in the form of the collisionless tearing instability can be stabilized due to the effect of the electrostatic field arising from the drift of trapped electrons due to the normal component of the magnetic field and the dawn-dusk tearing electric field. We consider recent results from theory, simulation, and observations to re-examine the status of collisionless spontaneous reconnection in the magnetotail. It is shown, in particular, that the electrostatic field of the tearing perturbation can be strongly reduced because of the small electron-to-ion temperature ratio due to the shielding effect of the transient electron population. This completely kinetic effect cannot be taken into account in the hybrid codes and it was missed in particle simulations due to short simulation boxes and reflecting boundary conditions imposed on the particles. Recent Geotail observations have convincingly shown that spontaneous reconnection may be actually the primary substorm trigger, and thus the stabilizing effect of trapped electrons can be overcome. Another important aspect of substorm physics is the formation of thin current sheets (TCS). These structures are thought now to play an important role in the energy transformation during substorms. Due to their extraordinarily small thickness (around the thermal ion gyroradius outside the sheet) TCS may have a very large portion of transient electrons. Therefore, they are especially promising as possible sites of reconnection through the tearing mode and the above mechanism of its destabilization due to transient electron population. We consider the latter effect for two basic TCS models, viz., electron dominated TCSs and forced current sheets.

S10-P01

THE MECHANISM OF X-RAY BRIGHT POINTS PRODUCTION

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Many observations show that X-ray bright points (XRBP) appear in the corona just after a new magnetic flux emergence. The most favorable mechanism of plasma heating is magnetic lines reconnection. The main problem connected with XRBP is the long existence (order of ten hours) of hot plasma in a little restricted regions of the corona. We propose the mechanism that includes plasma heating due to reconnection, and long stable confinement hot plasma in the vicinity of a neutral line. The conditions of confinement around a neutral line in the solar corona are similar to confinement in a thermonuclear trap with the magnetic field increased to the periphery. Equilibrium between magnetic pressure and plasma pressure is established. The plasma cooling is prevented, because of low thermal conductivity across the magnetic field. The heat transport occurs along the separatrix through very narrow magnetic slits. As a result two spots of visible radiation appear on the photosphere below XRBP. A possibility of particle acceleration in XRBP by the $-\boldsymbol{V} \times \boldsymbol{B}/c$ electric field is considered. This acceleration is, apparently, responsible for solar cosmic ray production in the quiet period of solar activity. Solving resistive MHD equations has simulated the proposed mechanism. The calculation shows that XRBP can appear in different magnetic field configuration with a neutral line. The PERESVET code is used.

S10-P02

MAGNETIC FIELD GENERATION AND SUBSEQUENT FIELD DISSIPATION WITH PLASMA HEATING IN RELATIVISTIC STREAMING PLASMAS

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Relativistic plasma streaming in background plasmas becomes unstable against the Weibel-type electromagnetic instability, which is one of effective mechanisms of magnetic field generation in cosmic plasmas. It is shown by using 3-D fully relativistic particle-in-cell simulation code that magnetic fields perpendicular to the stream are generated in the early stage of the instability with small-scale sizes of the electron skin-depth. In subsequent nonlinear stage there occurs magnetic reconnection which causes to make large-scale structure of magnetic fields in plasmas. The magnetic field dissipation through the magnetic reconnection leads to heating of the background plasma. These sequential physical processes are important for understanding of magnetic field generation in the relativistic shock of γ-ray burst sources in astrophysical plasmas.

S10-P03

MAGNETIC FIELD ENERGY DISSIPATION DRIVEN BY RELATIVISTIC PLASMA FLOW

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It is well known that magnetic reconnection in plasmas is one of very important energy conversion processes from magnetic field energy to plasma kinetic energy as well as high-energy particles. Magnetic reconnection driven by relativistic plasma flow is investigated by using a two-dimensional fully electromagnetic and relativistic PIC (particle-in-cell) code. We will propose the a process of effective energy conversion triggered by the streaming instability driven by relativistic plasma flow. The relativistic streaming instability can lead to the generation of the electric fields as well as the magnetic fields. Two components of the induced electric fields scatter the current-carrying particles and the magnetic field is subsequently dissipated. Energy dissipation rate of magnetic field driven by relativistic plasma flow is higher than traditional magnetic reconnection.

S10-P04

SIMULATION OF DYNAMICS OF CURRENT SHEET PRODUCED DURING TWO CURRENT LOOP COALESCENCE

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The coalescence of two parallel current loops in plasmas is investigated by a three-dimensional electromagnetic relativistic particle code. We investigate the current sheet dynamics produced by the complete magnetic reconnection. The formed current sheet is in a dynamical state. The localized current filaments are sequentially induced in the center of the current sheet, and are moving to the edge of the sheet. This process is repeated continuously until the current sheet disappears. We will also present the simulation results of nonlinear current sheet dynamics in later stage.

S10-P05

SIMULATION OF THE COLLISION OF MAGNETIC FLUX TUBES IN THE SOLAR PHOTOSPHERE

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The study of flux tubes dynamics near the solar photosphere is now fundamental importance to reveal coronal heating mechanism 1) 2). When two loops, which currents have same direction, approach each other, there occurs tearing instability in a current sheet where two loops contact. The tearing instability is shown to be greatly enhanced by ambipolar diffusion near the locations where two-dimensional magnetic fields reverse signs. The growth time is found to be on the order of the ambipolar diffusion timescale, independent of electrical resistivity. So we will present simulation results of reconnection rate due to tearing instability changing the ratio between ambipolor diffusion and resistivity coefficent.

1) *K. Furusawa and J. I. Sakai, ApJ.*, (2000) Sep. 10 issue.
2) *J. I. Sakai, T.Kawata, K. Yoshida, K. Furusawa and N. Cramer, ApJ.*, (2000) July 10 issue.

S10-P06

DISSIPATION OF MAGNETIC FIELD IN THREE DIMENSIONAL FORCE-FREE CONFIGURATION IN PLASMAS

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The dissipation process of magnetic field in three-dimensional force-free configuration is investigated by using three-dimensional electromagnetic and relativistic particle-in-cell (PIC) code. There occurs magnetic reconnection which leads to strong magnetic field dissipation. Almost all initial magnetic field energy can dissipate and is transformed to plasma heating, and high energy particles production.

S10-P07

MAGNETIC FIELD ENERGY DISSIPATION DUE TO PARTICLE TRAPPING IN FORCE-FREE CONFIGURATION OF COLLISION-LESS PLASMAS

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It is shown by using a two dimensional fully relativistic, electromagnetic particle-in cell (PIC) simulation code that a force-free magnetic configuration in collision-less plasmas becomes unstable against current-driven instability and subseqently there occurs a strong magnetic field energy dissipation associated with collision-less magnetic reconnection, which can be driven by particle trapping due to two dimensional electric potentials remaining in the nonlinear stage of the initial curent-driven instability. About 60 − 70 % of the initial magnetic field energy dissipates and is transformed to plasma heating as well as high-energy particle production.

S10-P08

NUMERICAL MAGNETOHYDRODYNAMIC SIMULATIONS OF MAGNETIC RECONNECTION TRIGGERED BY SHOCK WAVE

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We examined the magnetic reconnection triggered by shock wave generated by a point explosion by performing 2D resistive magnetohydrodynamic (MHD) numerical simulations with simple assumptions (*Tanuma et al.*, 2000). We found that the magnetic reconnection starts long after the fast-mode MHD shock wave passes the current sheet. The current sheet evolves as follows: (i) The tearing-mode instability is excited by the shock wave. The current sheet becomes thin in the nonlinear phase of tearing instability. (ii) The current-sheet thinning is saturated when the current-sheet thickness becomes comparable to that of Sweet-Parker current sheet. After that, Sweet-Parker type reconnection starts, and the current-sheet length increases. (iii) The secondary tearing-mode instability occurs in the thin Sweet-Parker current sheet. (iv) As a result, further current-sheet thinning occurs, because gas density decreases in the current sheet. The anomalous resistivity sets in, and Petschek type reconnection starts. The magnetic energy is released quickly while magnetic islands are moving in the current sheet during Petschek type reconnection. The total released magnetic energy and megnatic energy release rate are determined by the initial magnetic field strength, not energy of initial explosion nor distance to explosion.

Recently, we extend the 2D numerical simulations to 3D. All assumptions are same with those in 2D model except for the grid size and simulation region size. The magnetic reconnection occurs in the current sheet, which is similar to 2D model with the large glid size. We study the 3D effects on the magnetic reconnection.

S10-P09

THE INFLUENCE OF THE PLASMA ROTATION ON THE STRUCTURE OF MAGNETIC RECONNECTION

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Two rotating plasma filaments carrying electric current are considered. The Ampere force induces the filaments' coalescence, which is accompanied by the reconnection of the poloidal magnetic field. The results of numerical simulation show that the rotation strongly modifies the reconnection process, resulting in quasi-periodic (bursting) appearance and disappearance of a current sheet. Fast sliding motion of the plasma along the current sheet is a significant element of the complicated structure of reconnection. The magnetic surfaces in the overal flow are strongly rippled by slow magnetosonic perturbations that should result in the particle transport enhancement.

S10-P10

NUMERICAL STUDY OF MAGNETIC RECONNECTION PROCESS NEAR INTERPLANETARY CURRENT SHEET

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The third order accurate upwind compact difference scheme has been applied for the numerical study of the magnetic reconnection process possibly occurring near the interplanetary current sheet, under the framework of the two-dimensional compressible magnetohydrodynamics (MHD). Our results here show that the driven reconnection near the current sheet can occur in about $10 - 30$ minutes for the interplanetary high magnetic Reynolds number, $RM = 2000 \sim 10000$, the stable magnetic reconnection structure can be formed in hour-order of magnitude, and there are some basic properties such as the multiple X-line reconnections, vortical velocity structures, filament current systems, splitting and collapse of the high-density plasma bulk. These results are helpful in understanding and identifying the magnetic reconnection phenomena near the interplanetary current sheets.

S10-P11

RECONNECTION IN THE DAYSIDE MAGNETOPAUSE WITH SOUTHWARD AND DAWNWARD IMFS

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We have investigated the reconnection in the dayside with southward and dawnward IMFs using a three-dimensional electromagnetic particle code. After a quasi-steady state is established with an unmagnetized solar wind we gradually switch on a northward interplanetary magnetic field (IMF), which causes a magnetic reconnection on the magnetopause tailward of the dayside cusps and makes the magnetosphere dipolarized. In the case that the northward IMF is switched gradually to dawnward, there is no signature of reconnection in the near-Earth magnetotail in contrast to the case with the southward turning. On the contrary analysis of magnetic fields in the magnetopause confirms a signature of magnetic reconnection at both the dawnside and duskside flanks. The plasma sheet in the near-Earth magnetotail clearly thins as in the case of southward turning. Arrival of dawnward IMF to the magnetopause creates a reconnection groove which causes particle entry into the deep region of the magnetosphere via field lines that go near the magnetopause. The plasma ejection from the reconnection region with a southward IMF is investigated. We will also investigate the dynamics of inner magnetosphere including plasma injection with two different IMF orientations.

S10-P12

RAPID ION-ELECTRON MOMENTUM EXCHANGE VIA KELVIN-HELMHOLTZ INSTABILITY IN THE MAGNETOTAIL CURRENT SHEET

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Identification of instabilities responsible for dissipation in a current sheet is an important element in understanding the triggering mechanism of magnetotail reconnection. To this end, nonlinear dynamics of cross-tail instabilities (modes with wavenumber vectors parallel to the current sheet) are studied by two-dimensional full-particle simulations. High capability of recent super-computers enables us to carry out full-particle simulations with an ion-electron mass ratio (m_i/m_e) as large as 400. For a meso-scale current sheet (with half-thickness equal to an ion inertia length) initially carried dominantly by ions, we found that the Kelvin-Helmholtz instability (KHI) destabilized by the velocity shear between the lobe and the current-carrying ions comes to dominate after $\Omega_i T \sim 50$. The non-linear evolution of the KHI warps the plasma sheet significantly and excites lower hybrid drift (LHD) waves at its edge. This non-linear coupling between KHI and LHD waves produces rapid momentum exchange between ions and electrons, and thus resistivity. We think that this represents one of the realistic routes to an onset of dissipation. It is noted that this route is never found by runs with smaller mass ratio (< 200). in which artificially enhanced growth rates of the drift-kink instabilities smear out processes operative at the real mass ratio.

S10-P13

THREE-DIMENSIONAL RECONNECTION IN THE MAGNETOTAIL

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GEOTAIL satellite observational studies have revealed not only a critical role of magnetic reconnection in the dynamics of the magnetosphere but also an importance of ion kinetic processes in the magnetotail reconnection that show various non-Maxwellian ion distribution functions and would determine magnetic field structures. We have performed a number of large-scale three-dimensional hybrid simulations (ion particle, charge neutralizing massless electron fluid) of magnetotail reconnection. The results show that both plasma flows and magnetic field structures show asymmetric features in the cross-tail direction due to the ion kinetic and Hall term effects and are considerably different ones from MHD models in not only small scale but also large scale. The fast plasma flows generated by magnetic reconnection could make a coupling with the internal instability associated with the cross-tail direction in the thin current sheet and their front regions and would make complicated field configurations. We will also discuss differences of results related to different finite ky (the length of resistive region in the corss-tail direction) effects.

S10-P14

NUMERICAL SIMULATION OF BURSTY BULK FLOWS

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The numerical simulation of a bursty bulk flow is carried out by a 2-D Hall magnetohydrodynamic code. The code uses flux corrected transport technique. The equilibrium magnetic field is a 2-D flaring type model. The boundary of the simulation box is driven for a few seconds. The driver mimic the solar wind-magnetosphere interaction. This initial perturbation causes the magnetic reconnection in the inner plasma sheet. The dipolarization of the field ensues with earthward and tailward flows. The heating of the plasma sheet is compared with the analytical expression for the same. We see that the boundary driven reconnection of the inner plasma sheet may provide sufficient energy for a bursty flows.

S10-P15

SIMULATION OF SUBSTORM: MULTIPLE PLASMOID FORMATION

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We have solved the set of nonlinear differential equations governing the Geotail dynamics during substorm phenomena. The initial equilibrium configuration is assumed to be give by the fact that the magnetic pressure balances the kinetic pressure. The magnetic fields are generated by a thin current sheet with finite width and slowly varying along the tail axis. After the onset of reconnection a single plasmoid is formed which moves tailward with speed which depends on the initial parameters describing the current sheet. As the width of the plasmoid grows a second reconnection takes place at a distant tailward location; and a second plasmoid is formed. The second plasmoid moves tail ward, but the tailward velocity of the first plasmoid decreases. The time evolution of these multiple plasmoids are discussed with respect to the already known satellite observations.

S10-P16

MULTI-SCALE COMPUTER SIMULATIONS FOR THE STUDY OF MAGNETOTAIL RECONNECTIONS

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In the computational studies of magnetic reconnection, artificial resistivities were assumed and given in the simulation codes. We herein attempt to perform quasi self-consistent computer simulations for the study for the mechanism of anomalous resistivities. For this study, two simulation codes are sequentially combined: a 2-D hybrid code and a 1-D full particle code (KEMPO). First, a 2-D hybrid code is used to reproduce a plasma sheet thinning via compression of plasma sheet under the condition of additional magnetic pressure given to the lobe. This model is based on the fact that, before reconnections in the magnetotail, magnetic pressure is stored in the lobe region. In the first step simulation (via hybrid code) Harris condition are assumed as an initial state. Because of the high pressure in the lobe region, thinning of the plasma sheet takes place and then ion and electron are compressed. In this region we find that initial the Harris parameters change significantly; electron (and ion) are heated upto 5 to 10 times to the initial temperatures, and also electron (and ion) are accelerated in the dawn-to-dusk direction in the vicinity of the plasma sheet. These parameters lead to an unstable situation for micro-instability such as a two-stream instability or instabilities for ion acoustic wave. However, these micro-instabilities are beyond the study of hybrid code since this code does not include the electron kinetic effects. Thus, using the simulation parameters in this unstable region as an initial condition for the second simulation, full particle simulations are performed. Because of the development of the micro-instabilities, electron (and ion) drift energy decreases (effective current reduction) which leads to the "effective" anomalous resistivity. The amount of the effective resistivity is estimated from decrease of total cross-tail current between the initial and final states.

S10-P17

MASSIVELY PARALLEL THREE-DIMENSIONAL FULL ELECTROMAGNETIC (EM) PARTICLE-IN-CELL (PIC) SIMULATIONS OF GLOBAL RECONNECTIONS AND THEIR GLOBAL CHANGES OF MAGNETIC FIELD TOPOLOGY

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A massively parallel three-dimensional full electromagnetic (EM) particle-in-cell (PIC) code has been developed using recent parallel computation technology to simulate the interaction between the solar wind and the magnetosphere. The code is written in High Performance Fortran (HPF) so that the code is a portable and can be run on the different parallel computers so far as the HPF compiler is available. In our simulation, using Hitachi supercomputer SR2201, we performed particle simulations with more than 40,000,000 particles. Some basic kinematics behaviors of space plasmas in the magnetosphere is investigated. Those include the principal configuration of the magnetosphere. The significant features of the magnetosphere are automatically formed by the simulations. They are such as: bow shocks; magnetopause; magnesheath; magnetotail; plasma sheet; and polar cusps etc. In agreement with some important instabilities the simulation results indicate that the convection pattern across the entire polar cap begins to change a few minutes after the arrival of the southward IMF. In contrast, the onset of the equatorward motion of the open closed field-line boundary depending on the local time with equatorward motion of the midnight boundary delayed about 20 minutes relative to the onset of the boundary motion at noon. We interpret this delay as the time required to convect newly merged flux from the dayside to the nightside. In the simulations, we also investigate critical points that are magnetic nulls. They are located and characterized in a three-dimensional domain. The magnetic vector field curves and surfaces are integrated out along the principal directions of certain classes of critical points including the earth dipole magnetic field. Both the curves and surfaces are the characteristic ones. All the points, curves, and surfaces are uniquely linked to form a skeleton representing the three-dimensional vector field topology. Using this method, we also show the global changes of the magnetic field topology in the simulations.

S10-P18

PLASMA ACCELERATION ALONG THE TAIL MAGNETOPAUSE: EVIDENCE FOR THE LOBE RECONNECTION DURING SOUTHWARD IMF PERIODS

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It has been predicted that reconnection favors anti-parallel magnetic fields, thus preferentially occurs at the low latitude magnetopause for southward interplanetary magnetic field (IMF), whereas at the high latitude lobe magnetopause for northward IMF. The GEOTAIL spacecraft often encounters double-component ion populations along a thin layer between the magnetosheath and the distant ($X < -100\ R_E$) tail lobe. The two components flow tailward with different speeds, one with a speed higher than the magnetosheath flow, and the other with a lower speed. The two components are both smoothly linked with the magnetosheath ions, accompanied by the rotation of the magnetic field direction across the magnetopause. Our interpretation is that the field lines threading the layer are disconnected from the Earth through magnetic reconnection occurring on the tail surface. The higher-speed component is interpreted as the solar wind ions injected into the layer and accelerated tailward by the tension of the detached field lines, while the lower-speed component as the ions having been resident in the tail lobe before the detachment. These events are observed for northward and southward IMF conditions with almost equal probabilities, which means that the lobe reconnection occurs even for southward IMF periods, contrary to the above conventional view. We discuss favorable conditions and locations for the occurrence of the lobe reconnection for southward IMF cases.

S11-01

TOPOLOGICAL PHASE TRANSITIONS AND MULTISCALE SPORADIC LOCALIZED MERGING AND INTERACTIONS IN SPACE PLASMAS

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Natural phenomena describable with simple continuum topologies may undergo phase space transitions such that their ultimate behavior can only be understood in terms of higher order topological structures. In this talk, we shall discuss such transitions for dynamical systems far from equilibrium. Based on the physical concepts of resonances and coherent structures and mathematical formalisms of path integrals and the renormalization-group, we demonstrate that, from first principles, analogies may be established between equilibrium phase transitions and topological phase transitions. Examples in space plasmas will be provided to demonstrate these ideas.

S11-02

AURORAL DYNAMICS BASED ON CROSS COUPLING BETWEEN SOLAR WIND, MAGNETOSPHERE AND IONOSPHERE

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In the theoretical study of the solar wind-magnetosphere-ionosphere coupling, the energy entry processes, *e.g.*, magnetic reconnection and viscous interaction, have intensively investigated for many years by many authors. Whether reconnection or viscous interaction, its effect appears inside the magnetosphere as a movement of magnetic field lines which are terminated by the ionosphere. Since the ionospheric response is of the order of a minute, the reaction of the ionosphere cannot be ignored to understand the energy regulation in the solar wind-magnetosphere-ionosphere system. It appears that simulation studies on the reconnection process and the viscous process have now gone into a bit too details and would no longer produce new tasteful fruits. For a comprehensive understanding of the solar wind-magnetosphere-ionosphere dynamics, more efforts should be directed towards the construction of a consistent formulation connecting the solar wind entry process to the magnetosphere-ionosphere coupling. In this talk I wish to present one attempt toward that direction based on the classic Satos feedback interaction model between the magnetosphere and ionosphere.

S11-03

INTERMITTENCY AND SELF SIMILARITY IN MHD TURBULANCE: WHAT WE HAVE LEARNED FROM SPACE DATA ANALYSIS

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Solar wind offers us the unique opportunity to study in a space laboratory some processes which are important also from the point of view of fundamental physics. This opportunity has been particularly useful in trying to characterize the intermittent behavior of MHD turbulence. This behavior is related to the fact that the self similar hierarchy of the interacting eddies of different scale length displays a multifractal rather than fractal character. The analysis of solar wind data has allowed to identify both the phenomenology of the nonlinear cascade at work and the topology of the most intermittent structures. The multifractal character of the turbulent cascade can also furnish a key towards the understanding of some peculiar processes in plasma physics, where nonlinear effects play a fundamental role, as for example solar flares or edge turbulence in Reverse Field Pinch devices.

S11-04

ELECTRON-ION COUPLING IN HIGH MACH NUMBER SHOCKS: STRONG ELECTRON HEATING AND ACCELERATION

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Modern satellite observations revealed that the localized, large-amplitude electric fields with a bipolar signature are produced in the shock transition layer, which are thought to play an important role on the electron heating and acceleration. A strong ion and electron coupling is expected in the shock transition layer with the reflected ions for a higher Mach number regime. We study the electron-ion dynamics in a perpendicular magnetosonic shock wave by using the particle-in-cell simulation in the high Mach number regime. We find that a series of large amplitude, coherent electrostatic waves with the electron holes in the phase space are excited by the two-stream instability together with the lower frequency broadband waves. We discuss that collapse of the electron holes under the nonlinear interaction with the broadband waves leads to a strong electron heating and acceleration.

S11-05

WEAK TURBULENCE THEORY OF THE MAGNETOSHEATH FLUCTUATION SPECTRUM

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Experimental data of the magnetic fluctuations in the magnetosheath and in the vicinity of the magnetopause reveal several typical characteristics that have never been explained theoretically. We will mainly retain two of them. The first one is the existence of a power law spectrum in k^{-a}, much evoking the usual hydrodynamic turbulent spectra, but calculated here for the magnetic field (instead of the velocity); the index a is of the order of 3. The second point concerns the polarization: the kinetic linear theory tells that only one mode, the fast magnetosonic mode, should be able to propagate without damping above the ion gyrofrequency; although this mode is right handed, the experimental results always remain unpolarized. Both results strongly suggest that non-linear effects are at work. It is suggested that the energy source lies on the Alfvén mode at low frequency (large scale), and that mode coupling allow transfers toward higher frequencies via a continuous spectrum. The energy would eventually end on two different modes, the fast magnetosonic and the intermediate one, so confusing the polarization. The so-called intermediate mode is known, in kinetic theories, to be damped, but it could so be forced by the non-linear effects. We propose the first attempt to interpret the fluctuation properties in the frame of the weak turbulence theory and to quantify the suggested scenario. We start from the Hall-MHD system and characterize it by its Hamiltonian. When limited to quadratic terms, the solutions of Hamilton equations provide the linear solutions of the system, including, as expected, the fast magnetosonic and intermediate modes above the gyrofrequency. At third order, all mode coupling can be derived and the energy transfers from the low frequency Alfvén fluctuations toward the high frequency modes can be estimated.

S11-06

THE SELF-ORGANIZATION AND RELAXATION INTO THE MINIMUM ENSTROPHY STATE OF THE KELVIN-HELMHOLTZ INSTABILITY AT THE MAGNETOPAUSE

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The understanding of the nonlinear evolution of the Kelvin-Helmholtz instabilty at the magnetopause is important for clarification of the transport of momentum and energy of the solar wind into the magnetosphere. The evolution and relaxation of an initial shear flow subject to the Kelvin-Helmholtz instability at the magnetopause, which is far from equilibrium, are investigated by using two-dimensional MHD simulations and the calculus of variations. It is shown that the successive pairings of vortices occurring in the nonlinear stage of the Kelvin-Helmholtz instability is a self-organization process, which arises owing to the inverse cascade. This is demonstrated by showing that starting from the random perturbations with nearly white noise spectra, both the kinetic energy, the enstrophy, and the magnetic energy form power law spectra in the wavenumber space in the well developed nonlinear stage, which corresponds to the tail of the magnetosphere. In the real space the small-scale vortices excited by the instability near the dayside magnetopause evolve into global-scale vortices in the tail of the magnetosphere. When the magnetic field is perpendicular to the flow (or due north), a current eddy is associated with each flow vortex. During the instability evolution the total kinetic energy remains almost constant, but the enstrophy decays rapidly by the selective dissipation with the artificial viscosity. The final state in the flow attained in the simulation region, which is dominated by an isolated large vortex, is very close to the minimum enstrophy state, which is obtained by the calculus of variations assuming the minimum enstrophy with a constraint of the constant total kinetic energy and incompressibility. A quantitative measure of the thickness of the velocity shear layer near the subsolar point is obtained and the implication of the self-organization of the Kelvin-Helmholtz instability in the momentum and energy transport is discussed.

S11-07

MULTISCALE PROPERTIES OF WAVE-PARTICLE INTERACTIONS IN THE POLAR CUSP

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The polar cusp is the region in the plasma environment of the Earth where intensive conversion of energy takes place. Low frequency plasma waves which can control the dynamics of the ions in collision free plasma play very important role in the formation and behaviour of this region. This paper presents the review of the observations of the low frequency plasma waves together with plasma particles which were done by Interball-1, Magion-4, Magion-5 and Freja satellites in the different cusp regions. There are observed the accelerated plasma particles, hot electron populations and very strong wave activity, particularly at the low frequencies. The detailed study of the wave spectra together with the distribution function for electrons indicate the correlation between presence of the lower-hybrid waves and the population of the particles with higher energy then in the surrounding space. These experimental facts suggest that strong coupling between waves and particles is responsible for plasma heating. Freja data with high time resolution allow to find the process of the energy transport via cascade from low frequency waves through electron energization to high frequency waves. During polar cusp crossing by Interball-1 and Magion-5 the wave form has been transmitted occasionally by MIF and ULF experiments. The FFT analysis indicated many bursts of ULF emissions in both electric and magnetic components. These waves has highly non stationary characters. To study the dynamics of changes in the spectral characteristics of the waves the wavelet analysis has been used. In this presentation the results of the analysis for selected cusp crossings at different altitudes will be given.

S11-08

MULTIPLE SATELLITE OBSERVATIONS OF HIGH-LATITUDE IONOSPHERIC OUTFLOWS

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We will present reported observations of up- and down-flows of topside ionospheric thermal plasmas from multiple near-simultaneous tracks through the high-latitude topside ionosphere. From several Southern polar passes, it has been possible to construct plots of field-aligned flows of O^+ observed by the Thermal Ion Dynamics Experiment (TIDE) on the POLAR spacecraft near 5000 km altitude together with vertical ion flow observations from one or more DMSP spacecraft near 800 km altitude. We will also involve simulations from our Dynamic Fluid-Kinetic (DyFK) modeling of polar plasma transport and display resulting altitude profiles of ion parallel velocities and densities, and overlay those profiles with the "conjunction" measurements by DMSP (800 km) and POLAR ($\sim$ 5000 km altitude). We also will present simultaneous observations of POLAR auroral UVI images with field-aligned flows.

S11-09

SUDDEN DISRUPTION OF A THIN CURRENT SHEET

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The sudden disruption of thin current sheets during magnetospheric substorms is a phenomenon in which the dynamical coupling between large and small spatial scales of the magnetotail plays a crucial role. Until recently, the numerical simulation of this phenomenon, resolving all the relevant spatial scales, has been impossible. High-resolution Hall MHD codes which incorporate genuinely collisionless effects without abandoning the power and flexibility of MHD codes now enable us to resolve the collisionless physics of the magnetotail with realism. The impulsive growth and sudden disruption of a thin current sheet due to inward boundary flows in a collisionless plasma in which electron inertia breaks field lines, is presented. After a period of slow growth followed by a much shorter period of impulsive enhancement, the thin current sheet becomes unstable to secondary tearing instabilities which produce multiple islands. These secondary islands coalesce to form a large plasmoid and the thin current sheet disrupts rapidly to produce magnetic turbulence. It is found that the time scale of current sheet disruption is shorter than a characteristic Alfvén time. Results from Hall MHD simulations, including the effects of the Earth's dipole field, will be presented and implications for magnetotail substorms will be discussed.

S11-10

MULTI-SCALE PHENOMENA IN THE NEAR-EARTH MAGNETOTAIL

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The near-Earth magnetotail is recognized to be an important transition region between tail-like and dipolar field configurations. In this paper, we review observations of near-Earth plasma phenomena exhibiting multi-scale. The techniques employed in these observational studies include fractal, wavelet, sign-singularity, and wavelet bicoherence analyses. These investigations have led to better understanding of the inverse cascade process and nonlinear wave-wave coupling occurring at this interface region. The observational constraints on theories or models to account for these multi-scale phenomena are discussed.

S11-11

MULTISCALE RECONNECTION IN THE MAGNETOTAIL

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It is widely recognized that the earth's magnetotail plays essential roles in controlling global evolution of the magnetosphere. In this presentation we attempt to model its dynamics from the viewpoint of the complex dynamical systems (*Chang et al.*, 1998; *Zelyni et al.*, 1998; *Buchner*, 1998). We analyze both statics and nonlinear time evolution of the multi-scale turbulence in the system, as they are superposed with external noise. We first determine the relationship between the field spectrum and the field island cluster distribution, and then go on to discuss that an avalanche of reconnections can lead the system to a variety of different states: among them, at the percolation threshold, is the self-organized critical state characterized with a fractal island geometry. Implications of the results to the observed characteriscs of the magnetotail will be also discussed.

S11-12

PHASE TRANSITION-LIKE BEHAVIOR OF MAGNETOSPHERIC SUBSTORMS

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Studies of substorms using the solar wind VB_z and AL have shown that substorms are nonequilibrium transitions with phase transition-like behavior (*Sitnov et al., J. Geophys. Res.*, 2000). To overcome the limitations associated with the auroral indices data, a multispacecraft data set of the solar wind and magnetospheric parameters have been constructed. This data set comprises of the solar wind data from WIND, and magnetospheric data from Geotail ($-34\ R_E < X < -10\ R_E$) and Interball ($-28\ R_E < X < -10\ R_E$) spacecraft. The equivalent lobe magnetic field was calculated based on the simple pressure balance formula. To suppress the position-dependent changes along the tail axis the lobe magnetic field was reduced to $X = -20\ R_E$ using the statistical formula of *Fairfield and Jones* [1996]. The resulting set includes 7 intervals of substorm data with the duration from 40 to 80 hours each and 2 minutes time resolution. Many striking features of substorms are evident, *e.g.*, near coincidence of the lobe magnetic field time series data from Geotail and Interball, showing the coherence of the substorm dynamics on the largest substorm scales (more than several minutes and/or Earth radii). More detailed study of the new data set using the joint singular spectrum analysis of input and output data reveals signatures of the self-organization with the characteristic catastrophe manifold. The multiscale behavior of substorms, with features of avalanche, catastrophe, self-organized criticality and phase transition, is characterized as a non-equilibrium transition (NET).

S11-13

MULTISCALE COUPLING PROCESSES OF SUBSTORMS

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The observational features of multiscale coupling processes and a kinetic ballooning instability theory for substorms is presented. Based on the AMPTE/CCE spacecraft observations a new physical mechanism of the substorm onset and current disruption in the magnetosphere is proposed. Based on the AMPTE/CCE magnetic field data, a low frequency instability with frequency on the order of ion diamagnetic drift frequency is identified near the end of the late growth phase before the substorm onset when the plasma β reaches to a high value larger than 50. The instability continues to evolve during the substorm expansion phase. Just before the substorm onset an enhanced duskward ion drift of ion distribution is also observed and lasts only about one half of the wave period (about 30 sec) of the low frequency instability. The enhanced duskward ion drift is correlated with the excitation of higher frequency instabilities at the onset. After substorm onset, higher frequency instabilities strongly couple with the low frequency instability to form a plasma turbulence state during the substorm expansion phase. As a consequence, a large plasma transport takes place to cause plasma pressure profiles (averaged over the turbulent fluctuation scales) to evolve so that the magnetic field configuration changes from a tail-like to a dipole-like geometry. Moreover, enhanced tailward plasma flow also occurs. Thus, to understand the physical mechnaism of the substorm onset it is necessary to understand the observed low frequency instability wich occurs at high β (>50) and produces a duskward ion drift. We propose a new theory of kinetic ballooning instability which involves multiscale coupling of different spatial and temporal scales due to kinetic effects of finite ion Larmor radii and fast trapped electron dynamics.

S11-14

SELF-ORGANIZED MULTISCALE CURRENT SYSTEMS IN THE EARTH'S MAGNETOTAIL

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A large number of studies, both observational and theoretical, has clearly disclosed two qualitatively different regimes supporting the structural stability of the cross-tail current (CTC) systems: the "laminar", and the "turbulent". The "laminar" case is regularized in presence of a weak, but finite component of the magnetic field normal to the current sheet (CS) plane; the CTC is then carried by the nonadiabatic ions and is concentrated in meandering segments of their orbits trapped in the vicinity of the CS. If the normal component becomes sufficiently small, the CTC is stabilized by the self-organized magnetic field and plasma turbulence; such "turbulence-dominated" CS could be characteristic of, *e.g.*, the distant Earth's magnetotail, and the near-Earth tail during the late substorm growth phase. Self-organized "turbulence-dominated" CS reveals a number of unconventional features: The turbulence appears to be not "space-filling" but consists of hierarchical "clumps" separated by the multiscale "voids". We found that an effective tool in dealing with the "clumpy" turbulence might be the "fractal topology", (*i.e.*, the synthesis of the "conventional" fractal geometry and the differential topology of manifolds). This facilitates the proper description of the self-consistent coupling of currents and magnetic fields in the "turbulence-dominated" CS. The topological approach clearly shows that the Fourier image of the system exhibits the universal power-law spectrum with the index approximately equal to $-7/3$; such spectra have been observed in various in situ measurements of the turbulence both in the distant and near-Earth parts of the tail. As the free energy is accumulated in the system in the course of the substorm growth phase, the CTC becomes structurally unstable and spontaneously evolves from a multiscale pattern in the 2D CS to a 3D configuration; the phenomenon resembles the second order phase transition and can be associated with the formation of the current wedge at the substorm onset.

S11-15

MAGNETOSPHERE-IONOSPHERE COUPLING EFFECTS DURING SUBSTORMS IN THE POLAR MAGNETOSPHERE

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We examine observations of the POLAR spacecraft on a statistical basis to understand how the magnetic field perturbs in the polar magnetosphere during substorms, especially to see if it reflects any magnetosphere-ionosphere coupling effects. So far we have looked at the interval of one year from the launch of POLAR (in March 1996), and identified 76 substorms for which POLAR was located near its apogee (geocentric distance: 9 R_E). For the majority of the substorms, the magnetic field lines near POLAR became less tilted during the growth phase and recovered during the expansion to recovery phases. A possible explanation for this feature is as follows: When the field lines in the polar magnetosphere are pushed inward and tailward by the dayside-eroded flux piling up onto the polar magnetopause, they move accordingly, but their motion is decelerated at their footprints by the ionosphere, thus they become less tilted.

In order to see the validity of the above explanation, we have also run MHD simulations with the same solar wind input but different values of the ionospheric conductance. The simulation results show that the magnetic field tilt angle decreases rapidly under the condition of a large ionospheric conductance. This is consistent with the above explanation, because a large ionospheric conductance leads to an effective deceleration of the field lines at their feet.

S11-16

TYPICAL SCALES IN AURORAL INVERTED-V'S,STEADY ARCS AND ARC'S FILAMENTS

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Observations of steady auroral inverted-V's, auroral arcs and narrow arc's filaments show a significant time/space stability at their respective typical scales, that is, at ~ 100 km, ~ 10 km, and $\sim 0.1 - 1$ km. Physical origins of these scales in steady auroral features and coupling between them in auroral activation, or during substorm onset are discussed.

S11-17

KINETIC SIMULATIONS OF MULTISCALE TURBULENCE AN STRUCTURE FORMATION IN A PLASMA SHEET

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Observations have shown that the Earth's magnetotail is, at least in association with substorms, in an intermittent and turbulent dynamical state. We used kinetic plasma simulations of thin current sheets to model the turbulence properties of the tail. This way we investigated the transition to the formation of larger scale structures due to current instabilities and reconnection. The fluctuation spectra appear to follow multifractal power laws. We interpret the latter in terms of a transition between kinetic and hydrodynamic plasma processes.

S11-18

MULTISCALE TURBULENCE PRODUCED BY MHD-KINETIC-SCALE COUPLING IN AN IDEALIZED CURRENT SHEET MODEL

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From the global point of view, the substorm onset is a single explosive event that is controlled by a threshold-instability in the central plasma sheet. In the plasma sheet, however, we find a complicated process distributed nonuniformly both in space and, in particular, in time. It has become necessary to examine how the regular global substorm cycle can be controlled by the complex central plasma sheet.

We consider the possibility that the magnetotail current sheet is driven into self-organized criticality (SOC) by the solar wind-magnetosphere interaction, a possibility first suggested by *T. T. S. Chang*. An idealized current sheet model, containing a field reversal, is examined numerically. The model governs the evolution of the magnetic field on macro spatiotemporal scales, and it governs the evolution of an idealized current-driven instability on micro kinetic scales. The model is driven through the convection of opposing magnetic flux into the field reversal region at a steady rate. The result is fast field annihilation that is enabled by the interaction between the macro and micro model components. Evidence will be presented to show that when an equilibrium is established between the flux input and annihilation rates the model is near SOC. Specifically: (1) A loading-unloading cycle for the total field energy will be demonstrated that exhibits power-law burst size and duration distributions for internal activity plus a contribution from quasi-periodic global events. (2) Power-law power spectra for the field energy will be shown. (3) Power-law spatial and temporal power spectra for the field will be presented. (4) Internal avalanches will be defined and shown to exhibit scale-free power-law size and duration distributions as well as fractal structures on the

position-time plane. (5) Divergence of the model susceptibility will be demonstrated as the critical zero field limit is approached.

S11-P01

MULTISCALE STRUCTURES IN THE SOLAR WIND, FORESHOCK AND MAGNETOSHEATH BY MULTI-SPACECRAFT OBSERVATIONS

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Comparison of plasma observations by several spacecraft (INTERBALL-1, MAGION-4, IMP 8, WIND) in the undisturbed solar wind, foreshock and magnetosheath revealed many important features of plasma structures in these regions. The main part of solar wind plasma variations (probably coming from the Sun's surface) has a typical periods from several minutes up to several hours. The correlation lengths of these ion flux variations was evaluated for different SW conditions. Spatial scales of plasma structures in the range $10 - 100R_E$ were found to be strongly increased with the growth of their relative amplitudes of these variations. In the foreshock region in addition to those large-scale solar wind plasma variations much more faster fluctuations with shorter scales ($0.1 - 10$ R_E) and the periods in the range 2 – 50 seconds are generated. We found also that the plasma variations from the sources described above (solar wind and foreshock) are penetrating into magnetosheath. However it is very important that the major part of magnetosheath plasma variability has endogenous origin, *i.e.*, is generated locally inside the magnetosheath. These fluctuations have periods in the range from several up to several tens of minutes and their spatial scales sometimes could be as large as 10 R_E. Earth's magnetosphere is therefore subjected to the influence of this ensemble of multiscale variations of various origin which might have observable counterpart in the geomagnetic activity.

S11-P02

INVESTIGATION OF THE THICKNESS OF THE EARTH'S BOW SHOCK: GEOTAIL HIGH TIME RESOLUTION MGF DATA

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Ramp width of the Earth's Bow Shock was examined by using 16 Hz sampling magnetic field data. One hundred and three crossings of the bow shock were detected from magnetic filed data obtained from GEOTAIL during the period from March 26, to October 31, 1997 in the solar wind.

To obtain accurate ramp width, it is necessary to know accurate shock propagation speed and transit time of the shock crossing. large amplitude waves in the upstream make it difficult to determine the accurate start time of the shock transit. In our study, the start of the shock transit was determined from variation of the k vector in the upstream waves. The end of the shock transit was determined from the first peak that exceeds the average of magnitude of the magnetic field in the downsteam. The shock prapagation speed was calculated from coservation of mass and momentum. We have obtained accurate speed of the shock propagation for 16 crossings among more than 100 crossings. The shock ramp thus obtained were found to be $2-6$ times of the ion inertia length.

S11-P03

FREQUENCY DOMAIN ANALYSIS OF NONLINEARLY INTERACTING WAVE TURBULENCE IN THE MAGNETOSHEATH WITH TWO-POINT MEASUREMENTS

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Frequency domain modelling is used to identify linear and nonlinear processes in developed plasma turbulence in the magnetosheath.

It is shown that when choosing the appropriate regularisation technique the results obtained by frequency domain modelling are highly reliable.

The frequency domain method was applied to measurements of low frequency magnetic field turbulence measured by two-point satellites in the magnetosheath.

It is shown that an ion anisotropy leads to an excitation of an instability in various frequency ranges. However the wave growth in in these ranges is suppressed by the generation of nonlinear wave interactions which redistribute the energy towards higher frequencies.

S11-P04

MULTI-SCALE INTERACTIONS OF MAGNETOSHEATH FLOW WITH HIGH LATITUDE MAGNETOPAUSE

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We present both statistical and case studies of the magnetosheath (MSH) interaction with the magnetopause (MP) on the basis of high latitude Interball-1 and Polar data which are compared with the low latitude Geotail observations. MSH is highly disturbed just outside MP over the cusps and the mantle-LLBL interface in the tail. In this turbulent boundary layer (TBL) the characteristic maximum amplitude of the magnetic fluctuation is ~ 20 nT over the cusps and the characteristic scale of the fluctuations is $10 - 60$ s in their period, or $300 - 3000$ km in their wavelength. The largest scales observed are of the order of the curvative radius at the cusp throat ($1 - 3$ R_E). At the shortest scales, which drop to several electron inertial lengths, the plasma frozen-incondition is obviously violated. This suggests that intermittent secondary reconnection at these scales could provide both lasma transport and magnetic flux interconnection over the wide area of TBL/MP interface. Such small scale intermittent reconnection is superimposed on the medium scale (several thousands km) reconnection process operating locally at regions of anti-parallel average magnetic fields in the cusp throat. In several cases we've got the indications that reconnection might simultaneously operate quite far from the cusps in accordance with global MHD models. The characteristic scales there could be roughly estimated as a few R_E. We discuss the mechanisms of the energy transformation and plasma transport in TBL in terms of non-linear Alfvén wave dynamics and percolation.
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S11-P05

DUSK PLASMASPHERE OBSERVATIONS IN JULY – OCTOBER 1999: QUIET AND DISTURBED MAGNETIC CONDITIONS

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The ALPHA-3 instrument continuously functioning on INTERBALL 1 provided data on cold ion fluxes once per 4 days in July – October 1999, when the outer near equatorial part ($3 < L < 6$) of the dusk ($14.00 < MLT < 22.00$) plasmasphere was crossed. This period includes observations during enhanced magnetic activity on July 30, September 14 and 29, and October 22, which are of particular interest in connection with the Space Weather Month campaign. In these orbits the measured H^+ density was higher than it was observed in quiet conditions during other orbits. The plasmasphere size was reduced during periods of sustained substorm activity and detached plasma elements or extended plasmatails attached to the plasmasphere were occasionally observed. In-situ plasmapause observations are compared with ground-based data. The data are analyzed in conjunction with different theoretical models of the dusk plasmasphere dynamics.

S11-P06

ON THE STRONG INFLUENCE OF RANDOM HIGH-ENERGY PRECIPITATIONS ON THE PEDERSEN CONDUCTIVITY AND CURRENT SPREADING TO MIDDLE AND LOW LATITUDES

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The influence of stochastic non-homogeneities on the large-scale Birkeland current regions has been analyzed. The base line of the present study is an essential role of irregularities in the low ionosphere (80 – 100 km) and its contribution to the redistribution of quasistationary electric fields and currents in the high and middle latitudes. Such irregularities are caused by precipitating particles of the energetic spectrum 20 – 100 keV. According to estimates by [1, 2], these irregularities could contribute to the drastic increase of the electron part of Pedersen conductivity. The last makes possible that the ratio between Pedersen and Hall conductivity will inverse from regular value of 0.5 – 1.0 [3] to 10 in the case of the energy shift to the 100 keV band.

The global 3D-current distributions are studied within the framework of the direct task of dynamo theory for quiet geomagnetic conditions on equinox, using numerical simulation. Field aligned currents of Zone I [4] with the total intensity of 120 kA are taken into account as plausible initial sources. We have simulated role of the conductivity approximated by the Gaussian distribution with half-width 250 km, centered on the latitude $\jmath = 67.5°$. Results are presented for different ratio between Pedersen and Hall conductivities.

As the main result one could be pointed out that change of the Pedersen to Hall conductivity ratio associated with the small scale structure of the low ionosphere produces significant ionospheric currents spreading from high to middle and equatorial latitudes.

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S11-P07

A MAGNETOSPHERE-IONOSPHERE COUPLING MODEL FOR SUBSTORM GENERATION

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A time-dependent self-consistent model for the 3-D current system in the nightside magnetosphere is examined. An explosive increase in upward field-aligned currents in the nightside auroral zone is studied as a result of the magnetosphere-ionosphere coupling feedback instability. Since field-aligned currents close ionospheric currents, their magnitude is controlled by ionospheric conductivity. The undisturbed nightside ionospheric conductivity is small, and field-aligned currents are weak. Such situation takes place before a substorm. The cause of the instability is the effect of increasing upward field-aligned currents on the ionospheric conductivity that in turn stimulates a new increase in the field-aligned currents. At some moment the magnitude of the field-aligned currents becomes to be sufficient to accelerate precipitating electrons. This leads to a strong increase in the ionospheric conductivity and in field-aligned currents, which yields an explosive increase in auroral and geomagnetic activity. It is suggested that this instability may be related to substorm generation. The upward field-aligned currents in the midnight auroral zone are found to increase proportionally to square of the Pedersen ionospheric conductivity. Such strong dependence of the field-aligned currents on the ionospheric conductivity leads to very fast explosive increase in the magnitude of field-aligned currents.

S11-P08

INTERMITTENCY AND WAVE COUPLING IN MAGNETOSPHERIC TAIL CURRENT DISRUPTION

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Observations and analyses of tail "current disruption" (CD) evidenced the occurrence of large amplitude and turbulent magnetic fluctuations in the near-Earth neutral plasma sheet. These fluctuations have been shown to have an intermittent character and a self-similar structure. Recently *Consolini and Lui* (1999) showed that during CD a reorganization phenomenon takes place and that CD resembles the behavior of a dynamical phase transition. Here, we investigate the origin of intermittency in CD, looking to the occurrence of nonlinear wave coupling in the magnetic field fluctuations. Results are discussed in the framework of the hypothesis of an inverse cascading process and of a dynamical phase transition in a system out-of-equilibrium.

S11-P09

COMPLEXITY, CRITICALITY, AND FUNCTIONAL ORDER IN SUBSTORM DYANMICS

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Recent observations and anlyses evidenced that the magnetotail dynamics may be characterized by a scale-free behavior and intermittency. These results along with numerical simulations on cellular automata suggested that the observed scale-invariance may be due to "self and/or forced organized criticality" (FSOC) [*Chang*, 1999], meaning that magnetotatil operates near a critical point. On the other hand, a recent analysis [*Sitnov et al.*, 2000] of the magnetospheric response to solar wind suggests that geomagnetic substorms may resemble the behavior of a dynamical (first-order) phase transition. Moreover in the past it was extensively shown that global plasma instabilities play a relevant role at the substorm onset, meaning that just prior to the substorm magnetotail is near a point of marginal stability. Here we discuss the "dynamic complexity" of the magnetotail response, revising the "criticality" paradigm in the ligth of the previous observations, and introducing a new concept, the "functional order", emerging from the cross-scale coupling of macroscopic fluctuations.

S11-P10

EVIDENCE FOR A SOLAR WIND ORIGIN OF THE POWER LAW BURST DISTRIBUTION OF THE *AE* INDICES

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In this paper we examine the claim that the power law distribution of burst lifetimes in the AE index is evidence that the magnetosphere is a Self-Organized Critical (SOC) system. To do this we compare the burst lifetime distributions of the AU and $|AL|$ indices with those of the vB_s and epsilon solar wind input functions. We show for the first time that both the vB_s and epsilon burst lifetime distributions are of power law form with an exponential cut-off, consistent with the solar wind being an SOC or turbulent system. Furthermore, the power law of the epsilon burst lifetime distribution is not significantly different to that of the AU and $|AL|$ indices, indicating that this scale-free property of the AE indices could arise from the solar wind input and may not be an intrinsic property of the magnetospheric system. We discuss the implications of this result for SOC theories of the magnetosphere.

S11-P11

SELF-ORGANIZED CRITICAL TURBULENCE IN THE MAGNETOTAIL AS A FACTOR CONTROLLING THE SOLAR WIND-MAGNETOSPHERE COUPLING

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The phenomenon of spatial-temporal turbulence is known to play an important role in the dynamics of the Earth's magnetotail. The multiscale features of the turbulence can be interpreted in frames of the self-organized criticality (SOC) concept that provides a general explanation for the dynamics of many-body nonlinear systems with interactions. The generally accepted methodology for proving the magnetosphere is in the SOC state is through revealing power-law statistical distributions geomagnetic perturbations identified with the SOC avalanches. However, such observations provide only indirect evidence for the stable critical dynamics and can not be considered an exhaustive proof of SOC. In the present paper, we propose a new approach to the investigation of the critical turbulent dynamics of the magnetosphere. The analysis, based on the results of mean-field theory of systems with many absorbing states shows that, in addition to the algebraic probability distributions of fluctuating parameters, the SOC state typically demonstrates a critical scaling in terms of some averaged quantities. This important facet of a stable critical state should be represented in the dynamics of the magnetosphere but it has never been discussed before. More specifically, we investigate numerically the behavior of the zero field susceptibility as a function of dissipation rate in a running dissipative sandpile model. We show that, in accordance with the results of mean-field theory of SOC (*Vespignani and Zapperi*, 1998), the susceptibility diverges in the vicinity of a stable critical point. The power law scaling of the susceptibility may have a pronounced effect on the input-output characteristics of the magnetosphere and so can be used as a basis for experimental testing of the hypothesis of SOC.

S11-P12

STATISTICAL STUDY OF GEOMAGNETIC DISTURBANCES: POWER LAW AND THE SOC MODEL

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The magnetosphere is a nonlinear system, transforming an energy input from the solar wind to an energy output into the ionosphere and the inner magnetosphere. Recently, probabilistic models of nonlinear processes in the magnetosphere have been proposed [*e.g.*, *Chang*, 1998]. However, there seem to be little observational supports of these models. In this paper, we use the AL index to examine whether these probabilistic models are a reasonable approximation. The findings of our study can be summarized in the following way:
1. Employing a new method to count the number of geomagnetic disturbance "events" in terms of AL and to define the magnitude of each event, it is shown that the number of occurrence against the magnitude follows in general a power-law form, which is expected from probabilistic models.
2. The number of disturbance events does not fit to the power-law above a certain threshold in the magnitude. The existence of this threshold may represent that of a characteristic time-scale of magnetospheric processes or the corresponding spatial length of the magnetosphere.
3. The integral of the square of the AL values is used as a proxy for the energy dissipated in the ionosphere. The distribution of the number of disturbance events against that parameter is also found to fit to a power-law form. The power-law index is nearly 1.0, implying that a small number of intense events contribute more to the total energy dissipation than do a large number of weak events.

S11-P13

COUPLING OF THE LARGE-SCALE CURRENT SHEET SPATIAL STRUCTURE TO THE FINE SCALE STRUCTURE OF THE PHASE SPACE

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Forced current sheets (CSs) formed due to the interaction of the impinging ion beams from plasma mantle could be described analytically (*Sitnov et al.*, "*Problems of Geospace 2*", Wien, 165, 1999, *J.G.R.*, 2000, in press; *Malova et al.*, *AGU GM*, **118**, 2000, in press) using quasiadiabatic approximation (*Zelenyi et al.*, *Cosmic Res.*, **28**, 430, 1990). Weakly anisotropic CS exhibits interesting property – its global structure is very sensitive to the population of the phase space domains, which are not dynamically accessible from the external (mantle) regions. These particles are trapped within CS and presumably enter it via the sources other than plasma mantle (*i.e.* Low Latitude Boundary Layer). Although the total phase space volume occupied by this specific population is small, nonadiabatic currents carried by these particles are essential for the compensation of diamagnetic currents of mantle particles at the edges of the current sheet. Resulting profiles of the magnetic field are nonmonotonous and amplitudes of the magnetic humps depend on the fine structure of velocity distribution in the trapped domain. Matching - mismatching of the diamagnetic and meandering currents results in the appearance of the "flickering" solutions, *i.e.* oscillating between two limiting states. Strongly anisotropic CSs are not sensitive to this effect: phase volume of "trapped" domain rapidly shrinks with the growth of the anisotropy. Analytical model could relate the details of the shape of the measured magnetic field profile and the microphysics of non-adiabatic particle motion.

S11-P14

SCALING FEATURES OF VLF CHORUS OBSERVED BY MAGION-5

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We consider the VLF emissions observed by MAGION-5 in the morning sector at $L = 3 - 4$. The chorus emissions in dynamic spectra in the range of time scales $0.1 - 10$ Hz look like a self-similar set. This may be an evidence of the self-organized criticality of plasma in the area of their generation.The scaling features in chorus observation have been tested. It was found that the distribution of time between chorus is power-law with the exponent $d = 2.0 - 2.3$. The distribution of VLF amplitudes at the selected frequency have a power-law region with $d = 2.2 - 2.3$. At high frequencies this region is manifested better, than at low ones, where the noise interferes heavily. The comparison of characteristics of chorus emissions with the characteristics of hisses revealed their difference. For instance, the distribution of amplitudes at the frequency of 1 kHz in the plasmosphere hiss is of a purely noise nature, *e.g.* close to the uniform one with sharp decrease at high frequencies.

S11-P15

PARAMETRIC INSTABILITIES OF LANGMUIR WAVES IN THE PRESENCE OF EXTERNAL DENSITY FLUCTUATIONS

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We consider the interaction of the beam in the limit of marginal stability with perturbed plasma where there are externally excited density fluctuations. We simulate the Zakharov's equations in one dimensional long enough system and study the statistical properties of phases and amplitudes of primarily excited and secondary generated Langmuir waves. We choose the spectrum of density perturbations in the form of single-mode, several modes and wide-band spectrum. We analyze different regimes of the beam-plasma instability and study and analyze statistical properties of the Langmuir waves turbulence.

S11-P16

NEAR-EARTH CURRENT MEANDER [NECM] MODEL OF SUBSTORMS

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We propose that the appropriate instability to trigger a substorm is a tailward meander of a strong current filament that develops during the growth phase. From this single assumption follows the entire sequence of events for a substorm. The main particle acceleration mechanism in the plasma sheet is curvature drift with a dawn-dusk electric field, leading to the production of auroral arcs. Eventually the curvature becomes so high that the ions cannot negotiate the sharp turn at the field-reversal region, and the particle motion becomes chaotic causing a local outward meander of the cross-tail current. An induction electric field is produced by Lenz's law; an outward meander with $B_z > 0$ will cause flow out from the disturbance, macroscopic electromotive instability. The response of the plasma is through charge separation and a scalar potential. Both types of electric fields have components parallel to a realistic magnetic field. Part of the response is the formation of field-aligned currents producing the well-known substorm current diversion. This is a direct result of a strong field-aligned induction electric field (the cause) needed to overcome the mirror force of the current carriers (the effect). However, with zero curl, it cannot modify the emf of the inductive electric field (property of vector fields); the charge separation that produces a reduction of parallel component must enhance the transverse component. The new plasma flow becomes a switch for access to the free energy of the stressed magnetotail. Near the emerging X-line particles will be accelerated non-adiabatically to moderate energies in a weak magnetic field, and then by gradient and curvature drift to attain high energies.

S12

S12-01

CUSP LATITUDE TRANSIENT PULSATIONS: SOLAR WIND CORRELATIONS AND DIURNAL PATTERNS

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Magnetic Impulse Events (MIEs), Pi 2 Bursts, and Intervals of Pulsation Continuous-Long (IPCL) are common terms used to describe the transient nature of long period ($T \sim 100 - 1000$ sec) ULF waves recorded by high latitude (mlat $\sim 75°$) ground based magnetometers. We have examined data from the cusp latitude station of Davis, Antarctica and simultaneous upstream solar wind data from the WIND and IMP-8 spacecraft and found many transient events in which either solar wind dynamic pressure changes or sporadic reconnection are the possible drivers. Changes in IMF orientation are often accompanied by pressure pulses making it difficult to separate generation mechanisms. We have selected 4 individual days with solar wind conditions ranging from typical to extreme, and found some clear correlations with pressure pulses or IMF changes alone. Spectral analysis is used to determine polarization and propagation characteristics of these events thereby providing further insight into the possible generation mechanisms. Clear diurnal patterns are observed on days of typical solar wind conditions. Under more extreme conditions a dependence on IMF B_y emerges which can be explained by the control of high latitude convection by the IMF clock angle.

S12-02

CHARACTERISTICS OF Pc 3 and Pc 5 WAVES OBSERVED BY THE AGO NETWORK AT SOUTHERN HIGH LATITUDES

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Using ULF wave data measured by search coil and fluxgate magnetometers installed at six Automatic Geophysical Observatories (AGOs) locating from 70° to 87° magnetic latitude and South Pole station at 74° magnetic latitude, the characteristics of Pc 3 and Pc 5 waves have been investigated in detail. It is found that Pc 3 waves with a narrow-band structure are frequently observed at these latitudes, and that the frequencies of the spectral peaks coincide with the frequencies of upstream waves excited near the bow shock, suggesting that these Pc 3 waves are originated from upstream waves. It is also found that damped-type Pc 5 waves occur frequently at AGO P2 and P3 at 70° magnetic latitude when magnetic impulse events (MIEs) occur at AGO P1 and P4 at 80° magnetic latitude. Alfvénic magnetic field and velocity fluctuations are often observed in the solar wind during these events. The generation mechanisms of Pc 3 and Pc 5 waves in the outer magnetosphere are discussed based on the characteristics of these waves.

S12-03

COORDINATED SUPERDARN AND GEOTAIL OBSERVATIONS OF Pc 3 PULSATIONS

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In spite of accumulated observations of ULF pulsations, there is no satisfactory explanation for the generation and transmission mechanisms of Pc 3 pulsations at very high latitudes. Therefore, we have studied the characteristics of high-latitude Pc 3 pulsations using data acquired in the ionosphere by the SuperDARN radars and in space by the GEOTAIL satellite. The observations revealed that narrow-band Pc 3 pulsations are occasionally observed in Doppler velocity data by the HF radars, and that there is a clear peak of the Pc 3 power. We also found that the latitudinal variations of power of Pc 3 pulsations depend on the cusp location. Furthermore, we found that compressional magnetic field variations in the dayside magnetosheath include spectral peaks identical to the Pc 3 pulsations detected by the radars. The results suggest that the driving source is located outside the magnetosphere, and that part of the energy of driving source is transmitted into the ionosphere along cusp/LLBL magnetic field lines.

S12-04

ATTENUATION OF A Pc 5 PULSATION

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An interplanetary shock interacted with the Earth on 18.02.1999 and excited an intense transient Pc 5 pulsation. Analysis of the spatial variations and the time variations of the pulsation induced electron drifts in the high latitude ionosphere, allows a deduction of the latitudinal variation of the height integrated Pedersen conductivities. It is concluded that ionospheric Joule heating losses are sufficient to account for the attenuation of the pulsation. It is also shown that for a pulsation event of this type use of magnetometer observations lead to an overestimate of the attenuation, or, equivalently, to an underestimate of the ionospheric Pedersen conductivity.

S12-05

POSSIBLE SCENARIO OF HIGH-LATITUDE Pi 2 PULSATION EXCITATION

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We studied the association between high-latitude Pi 2 pulsations and auroral intensifications observed at stations from 210 deg MM chain. It is firstly found that there is close relationship between the characteristics of high-latitude Pi 2 pulsations and parameters of wave-like and vortex auroral structures of 50 – 200 km scale in the brightening auroral arc: (a) the maximum Pi 2 amplitude is observed at the same latitude where the auroral arc is located; (b) the period of high-latitude Pi 2 pulsations is consistent with the ratio of the luminosity wavelength to their propagation velocity and/or coincides with the lifetime of luminosity bright spots; (c) the Pi 2 polarization patterns are defined by the direction of luminosity bright spot rotation and depend on location of the observational station relative to the auroral arc.

These results allow to suggest a new scenario of Pi 2 excitation according to which the spectrum of high-latitude Pi 2 pulsations is formed with the development of Kelvin-Helmholtz instability, responsible for the generation of the auroral structures of an arc. Fluctuations of the electric field and ionospheric conductivity in the range of Pi 2 periods will led to the spatio-temporal current system oscillations of the auroral arc which are observed on the Earth as high-latitude Pi 2 pulsations.

S12-06

TRANSIENT BEHAVIOR OF THE MHD WAVES BASED ON THE CURRENT WEDGE MODEL: A MODEL OF THE Pi 2 PULSATION

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Transient behavior of the MHD signal induced from a localized, impulsive magnetospheric current is dealt with as a model of the Pi 2 pulsation by using the magnetosphere model having the dipole magnetic field and the ionosphere with the Pedersen conductivity. The impulsive current is the magnetospheric part of the current wedge model. Numerical calculation revealed the following: 1) The impulsive current induces the plasmasphere virtual resonance oscillation and the field-line resonance oscillation. 2) The waveform of the compressional magnetic perturbation in the plasmasphere depends on the spatial extent of the source current, its temporal variation, as well as its location. 3) The typical Pi 2 waveform in the plasmasphere is obtained when the source current is located near the plasmapause ($L < 10$). 4) The ionosphere controls not only damping of the field-line resonance oscillation but also its frequency. 5) The field-line resonance oscillation exhibits the fundamental mode structure along the field line in the plasmasphere and a combination of the fundamental and higher harmonic oscillations outside the plasmapause. In high latitudes, there are waves bouncing between the ionospheres. This suggests that the waveform in the middle- and low-latitudes is different from that in high-latitudes.

S12-07

PLASMASPHERIC DYNAMICS EXPLORED BY GROUND OBSERVATIONS OF ULF AND VLF WAVES

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The whistlers in the VLF band have been instrumental as a tool of probing the electron density in the magnetosphere and exploring the dynamics of the plasmasphere. In recent years, a similar use of ground measurements of ULF waves for probing the plasma mass density has also been found feasible after the gradient method proved itself a useful identifier of the resonant frequencies of magnetospheric field lines. In this study, we present the observations of the dynamic plasmasphere using both methods. The equatorial plasma mass densities are inferred by the pulsation observations from the IGPP magnetometers at $L = 2$ and the Fort Churchill line of the CANOPUS magnetometer array at $L = 4 - 10$. In addition, the electron density calculated by curve-fitting the whistlers observed at the Palmer station, Antarctica ($L = 2.4$), is also studied for comparison. Special attention is paid to the strong depletion of the plasmasphere at low latitudes during the September 1998 magnetic storm. Ground pulsation data show that the plasma mass density dropped significantly to approximately a quarter of the pre-storm value at $L = 2$ during the first day of the storm. A similar decrease of the electron density inferred by whistlers is also found. The combined use of both measurements may reveal important information about the ion outflow from the ionosphere during this magnetically active interval. Also discussed will be the possibility of incorporating the parametric density formula along the field line based on the best selection of statistical models.

S12-08

THE WAVE CHARACTERISTICS OF THE GLOBAL COHERENT Pc 3 PULSATIONS

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The coherent Pc 3 pulsations oscillating in a nearly in-phase relation over a wide range of latitude ($L = 1.0 - 5.5$) are often observed by the ground-based magnetometer network observations. That indicates that there may exist the global mode oscillations such as the plasmaspheric cavity mode oscillations or the global current system in the ionosphere.

The wave characteristics of the global coherent Pc 3 pulsations have been studied by using data from the Circum-pan Pacific Magnetometer Network, which consists of the 210 degrees magnetic meridian stations from the dip equator to polar region and the longitudinally-separated stations near the magnetic equator. To begin with, the longitudinal spatial structure of Pc 3 pulsations observed near the magnetic equator was investigated in detail by the fast Fourier transform (FFT) analysis. The H-component Pc 3 pulsations detected simultaneously at different local times between 0730 and 1800 LT were found to be nearly in-phase (< 40 degree). A 180-degree phase jump of the H-component Pc 3 pulsations occurs across 0730 LT. Then, for the horizontal components of all latitudinally-distributed stations, the spectral parameters such as coherence, amplitude ratio, and phase difference were investigated statistically by using the H component of the equatorial station, Guam ($L = 1.01$), as a reference. After considering the longitudinal spatial structure of the reference Pc 3 pulsations, MLAT-LT maps of the spectral parameters were achieved. Finally, we obtained the ionospheric equivalent current system of the coherent Pc 3 pulsations. The equivalent current system

shows two vortices, which are centered at 0700 LT and 1330 LT around 60 degrees in magnetic latitude. We suggest that these vortices may be attributed to the efficient mode conversion from magnetosonic waves into Alfvén waves near the plasmapause.

S12-09

MAGNETOSPHERIC DIAGNOSTICS USING ULF WAVES

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Ultra-low frequency (ULF) plasma waves distribute energy of solar wind origin throughout the Earth's magnetosphere and down to the ground, where they are recorded as pulsations of the geomagnetic field. The waves propagate in the fast magnetosonic mode within the magnetosphere and may couple to cavity or waveguide modes or shear transverse mode field line eigenoscillations. Ground magnetometer arrays can therefore be used to examine properties of near-Earth space, providing an important complement to VLF and spacecraft studies. We present results showing that it is possible to monitor variations in plasma throughout the dayside magnetosphere, with a temporal resolution of order 15 min. Specific issues that can be investigated include the plasma mass loading, the plasma density power law, diurnal variations in plasma density, location and properties of the plasmapause, and substorm refilling effects. Such observations provide important input to mathematical models of wave propagation in the coupled magnetosphere-ionosphere system.

S12-10

DIAGNOSTICS OF SOLAR WIND-MAGNETOSPHERE INTERACTIONS USING GROUND-BASED OBSERVATIONS OF BROADBAND ULF WAVES AT HIGH LATITUDES

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Long-period broadband waves ($\sim 1-10$ mHz) have been known for many years to be a dominant feature in the cusp-latitude ULF wave spectrum. Several features of these waves can be used as diagnostics of solar wind–magnetosphere interactions, although many show complexities not yet understood: 1) Increased velocity shear between the solar wind and magnetosphere is the major source of such waves; broadband wave power shows a power law correlation with V_{sw} at both auroral zone and cusp latitudes. However, wave activity is both more broadbanded and more intense during the initial stages of major geomagnetic storms than during the main phase, suggesting the presence of additional controlling factors. 2) The intensity of these waves is also correlated with precipitation of energetic particles near the magnetospheric boundary. In fact, quantitative estimates based on riometer and photometer observations indicate that variations in electron precipitation are sufficient to drive the broadband pulsations. 3) Wave activity is often not simultaneous in both hemispheres. This suggests a possible source in the high-altitude cusp or entry layer regions in each hemisphere, rather than or in addition to a common source in the equatorial or mid-latitude magnetosphere. 4) We have so far found little correlation between ULF variations in solar wind velocity and/or pressure and ULF wave power at these latitudes. This negative result goes beyond a simple correlation between such variations and Vsw, in which case their influence on the magnetosphere would be subsumed under 1) above.

S12-11

IONOSPHERIC EFFECTS ON ULF WAVES

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We use two-fluid or Hall effect MHD description of weakly-ionized stratified atmosphere to describe several polarization features of the ULF wave disturbance penetration. We derive an approximation to the case of the MHD waves in the Earth's Hall ionosphere and demonstrate its different polarization responses (ellipticity and rotation) for Alfvén (TM) and fast magnetosonic (TE) modes depending on the Hall region thickness. Neglecting the Hall thickness effect we derive previously obtained, well-known results for the rotation of the polarization plane of the MHD waves. The ionospheric effects are more essential for the polarization of the TE waves. The polarization changes of the magnetosonic waves are expressed as a function of i) the ratio (R) of the height-integrated Hall (SH) and Pedersen (SP) conductivities (conductances) in the Hall region and ii) a wave/magnetospheric parameter (Am) and the ratio Am/SP. The wave/magnetospheric parameter Am depends on the wave frequency and the horizontal scale of the ULF waves. Using standard models (IRI 90 and MSIS 86) responses of ULF magnetosonic waves to seasonal/diurnal ionospheric variations at subauroral/middle latitudes are illustrated for arbitrary, but reasonable values of the wave/magnetospheric parameter Am. Along with the rotation effect an ellipticity effect has also local time (LT) course. These findings suggest a dominant dissipative mechanism (non-resonant) of transformation of magnetosonic waves into Alfvén modes in the ionosphere. A condition for such a transformation is obtained. In addition, we suggest a physical insight for the MHD wave transformation effects by the ionosphere.

These findings should be taken into account for the analysis of various polarization features of the geomagnetic pulsations observed on the ground. Sunrise effect on the polarization of the Pc 3-4 pulsations, the effect of transformation of pure compressional ULF disturbance in the magnetosphere into transverse wave on ground is explainable in terms of both the polarization rotation and the ellipticity mechanism by the ionosphere. Simultaneous measurements of the electric and magnetic field of ULF waves at ground and balloon heights have revealed polarizations of opposite

handedness. It is shown that the polarization changes of the magnetosonic wave through a horizontally homogeneous high-latitude ionosphere continues further through the atmosphere and would result in different polarization states for the electric and magnetic fields. The northern (southern) hemisphere ionosphere causes an additional left (right)-hand polarization effect in the ionosphere/atmosphere produced mostly on the ULF wave magnetic field. The opposite handedness of the Pc 5 wave polarization recorded at the South Pole by measurements of the ULF electric and magnetic field components might be explained as a result of an influence of the ionosphere on the TE ULF waves of an initially left-hand polarization.

S12-12

GROUND IMAGE OF WAVE PROCESSES IN A DISTANT MAGNETOSPHERE DUE TO THE MHD MODE CONVERSION

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The feature of MHD wave processes in space and laboratory plasmas is the possibility of the resonant conversion of global compressional modes into localized Alfvén oscillations. This way MHD signals excited by local non-steady processes in remote parts of the magnetosphere can convey information to the ground. Several examples are considered:
- Ground-based hydromagnetic diagnostics of the magnetospheric plasma with the use of Pc 3-5 waves;
- Turbulence in the high-altitude polar cusp and dayside band-limited Pc 3 pulsations at high latitudes;
- Bursty processes in the middle magnetotail and localized response at the auroral boundary;
- Pumping of energy by Pc 5-6 ULF pulsations into an auroral arc.

S12-13

DIAGNOSING THE EXCITATION MECHANISMS OF Pc 5 ULF MAGNETOSPHERIC WAVEGUIDE MODES AND FLRS

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Global oscillations of the magnetosphere can be excited by both variations in solar wind ram pressure, and through the development of Kelvin-Helmholtz (KH) shear-flow instabilities at the magnetopause. These solar wind drivers can excite a discrete spectrum of ULF waveguide modes, each of which can resonantly drive localised field line resonances (FLRs). Theoretical modelling shows that the reflectivity of the magnetopause is critically dependent upon the changes in the background sound and Alfvén speeds across the magnetopause. The near-noon magnetopause is leaky, and hence the quality of the global magnetospheric cavity is low. On the flanks, however, the reflection coefficient is larger, the magnetopause can become perfectly reflecting, and under conditions of fast magnetosheath flow the KH instability can energise waveguide modes. The characteristics of the FLRs excited by the waveguide modes are hence expected to be strongly local time dependent, and we present observations from ground-based magnetometers in support of the theory. In particular, in the case when multiple harmonic waveguide modes are excited, the observed values of the multiple FLR phase velocities can be used to distinguish between waves excited by solar wind impulses or magnetopause shear-flow instabilities. Moreover, the observed Alfvén continuum, which can be determined from the magnetometer data, can be used to infer the morphology of the magnetosphere at the time. Thus ULF waves provide a diagnostic tool both for determining remotely the characteristics of energy injection from the solar wind into the global magnetosphere, and for inferring some of the properties of magnetospheric morphology at the time.

S12-14

ELECTROMAGNETIC ION CYCLOTRON WAVES IN THE EARTH'S MAGNETOSPHERE: ARE THEY BOUNCING WAVE-PACKETS?

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It has been commonly accepted over the last twenty-five years that electromagnetic ion cyclotron (EMIC) waves propagate in the middle and outer magnetosphere as discrete wave packets bouncing along geomagnetic field lines between hemispheres. This argument has been supported by the observations of EMIC waves seen on the ground in the Pc 1 ($0.2-5$ Hz) band as bursts of band-limited energy which were 180 out of phase between hemispheres. They also showed a time separation indicative of an Alfvén double-hop bounce period, which increased with increasing latitude. Under this scenario, a spacecraft located at high altitude in the equatorial region and in the path of a bouncing wave packet would be expected to see that wave packet passing by in one direction followed by a return pass in the opposite direction, and with bounce period twice that seen on the ground. However, recent satellite results from AMPTE, CRRES and POLAR suggest that energy propagation is primarily unidirectional, away from the equator. Also, IPDP and other unstructured emissions may show different bounce properties to those associated with the more regular structured pearl-type emissions. This study will revisit the properties of EMIC wave packets observed on the ground using data from the near-conjugate locations of Fairbanks, Alaska and Macquarie Island. Other evidence to explain the bouncing wave packet phenomena, including modulation by long period ULF waves will also be discussed.

S12-15

HIGH RESOLUTION OBSERVATIONS OF ULF WAVES IN THE IONOSPHERE USING THE DOPE HF DOPPLER SOUNDER

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The Doppler Pulsation Experiment (DOPE) is a fixed frequency multi-path HF Doppler sounder, which continuously monitors the ionosphere in the vicinity of Tromsø, Norway. ULF wave signatures cause small variations in the radio phase path of the diagnostic signals, detectable by DOPE. Due to its high spatial resolution, the sounder is able to observe waves with small spatial scale sizes (large m-numbers). This has lead to the classification of a number of different types of waves driven by wave-particle interactions involving drifting energetic particles in the magnetosphere. Recent DOPE observations of these waves will be presented and their source mechanisms discussed.

S12-16

TRANSPORT AND ACCELERATION OF RADIATION BELT ELECTRONS THROUGH RESONANT INTERACTION WITH MAGNETOSPHERIC ULF OSCILLATIONS

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Energetic electrons in the outer-zone radiation belt show substantial variability over a variety of time scales, and can pose a significant hazard to spacecraft operating in this environment. Understanding the nature of these variations, both empirically and physically, has therefore become increasingly important. There has been significant observational evidence linking enhancements in relativistic outer zone electron fluxes with both the presence of magnetospheric ULF oscillations in the Pc 5 frequency range, and with increased solar wind speeds. The existence of Pc 5 waves in a non-axisymmetric dipole magnetic field, such as formed by the Earth's magnetic field under the influence of the solar wind, can lead to the efficient radial transport and acceleration of trapped magnetospheric electrons. The rate at which these electrons are accelerated increases with both increasing radial distortion in the magnetic field and increasing Pc 5 ULF power, and can lead to electron flux enhancements on time scales commensurate with those commonly observed during magnetic storms associated with high-speed solar wind streams. In this work we examine the nature by which ULF oscillations can act to accelerate relativistic electrons, and present expressions for the characteristic time scales over which flux enhancements can occur.

S12-17

PLASMA WAVES NEAR EARTH'S BOW SHOCK AND THEIR IMPLICATION

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The Earth's bow shock is one of the regions where intense plasma waves can be observed. Since the earlier plasma wave investigations around the bow shock were conducted mainly by spectrum receivers, they did not succeed in detecting short-lived waveforms or wave phase information. Wave-Form Capture receiver (WFC) onboard Geotail spacecraft was newly developed for collecting the waveform data of electric and magnetic field components up to 4 kHz. The waveform observations by this WFC receiver have successfully revealed detailed wave structures in the upstream region, the bow shock transition layer and the downstream region. Especially, the success of the high time resolution waveform observations in the bow shock transition layer allows us to discuss the detailed plasma processes in the very interesting region where the plasma status and parameters change drastically. The observed waveforms in the bow shock transition region are classified into (1) Electrostatic Solitary Waves (ESW), (2) Electrostatic monochromatic waves (Ion acoustic like waves), and (3) Electromagnetic monochromatic waves. The Electromagnetic monochromatic waves of (3) are continuously observed during the passage through the transition layer. However, the waveforms and frequencies of the electrostatic waves of (1) and (2) change very quickly within an order of a few milliseconds. The abrupt change of the nature of the electrostatic waves is frequently observed in the transition region and downstream region. This fact suggests that electron dynamics dominate in generating these electrostatic waves. In the present paper, we will introduce the detailed plasma wave features around the Earth's bow shock region and discuss the possible generation mechanisms consulting computer simulation results.

S12-18

DEVELOPMENT OF TURBULENCE DURING MAGNETIC RECONNECTION AT THE MAGNETOPAUSE

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Satellite observations indicate that the magnetopause is a region of intense wave activity. The electric and magnetic field spectra are typically broad, with amplitudes which are correlated with the degree of magnetic shear across the magnetopause. The nature of this turbulence, including the drive mechanism, and its ultimate impact on the structure of the magnetopause has been poorly understood. The development of computational tools for exploring the magnetic reconnection in 3-D collisionless systems is allowing a self-consistent exploration of reconnection in a system with fully developed 3-D turbulence. The electron and ion scale boundary layers and beams which develop as a result of reconnection drive instabilities, which in turn feed back on the reconnection process, altering the boundary layer structure. Instabilities driven by both field aligned and cross-field sheared electron flows drive turbulence which is localized along the separatrices and around the x-line. The lower-hybrid-drift instability is strongly destabilized on pressure gradients flanking the outflow region. A surprise is that very little particle transport or anomalous resistivity is associated with the resulting fluctuations. The overall impact of turbulence on the reconnection rate is minimal, consistent with the insensitivity of the reconnection rate to electron dissipation in the 2-D system. Fluctuation spectra will be presented.

S12-19

VLF WAVE SCATTERING AND DIFFUSE AURORAL PRECIPITATION

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It is generally believed that the Earth's diffuse aurora is a result of rapid pitch-angle scattering of plasma sheet electrons. Because the magnetosphere is essentially collision-less, the scattering must be caused by wave-particle interactions. Although several scattering mechanisms have been proposed, there is still no general consensus of the dominant process. Plasma sheet electrons are able to resonantly interact with two principal classes of plasma wave; electrostatic electron cyclotron hamonic (ECH) waves and electromagnetic whistler-mode chorus. Preliminary calculations will be presented of the rate of pitch-angle diffusion by each class of wave based on new information on the power spectral density of the waves under different levels of magnetic activity. An assessment will be made of the relative importance of each scattering process to the diffuse aurora.

S12-20

A THEORY OF DISCRETE VLF EMISSIONS IN THE MAGNETOSPHERE

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The generation of chorus and triggered VLF emissions is considered with common viewpoint. The keystone of this gerenation mechanism is whistler-wave interactions with well organized electron beams. In the case of triggered emissions, these beams are produced by initial pump wave packets and have very small dispersion over the field-aligned velocity component $v_{\|}$. In the case of chorus emissions, an electron beam has the form of a sharp step over $v_{\|}$, which appears at the boundary between resonant and nonresonant electrons as a consequence of quasilinear relaxation of the cyclotron instability. Two basic processes determine the temporal behavior and dynamical frequency spectrum if signals for both types of discrete emissions. These are the second-order cyclotron resonance effect and transition to the absolute instability that manifests itself as the backward wave oscillator (BWO) generation regime. Theoretical results are discussed in application to interpreting the known experimental data. It is shown that the concept developed allows one to give a consistent interpretation of the data.

S12-21

SUBSTORM CHORUS EVENTS: WHAT ARE THEY AND WHAT CAN THEY TELL US?

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Clouds of energetic electrons injected near midnight during substorm expansion phase onset drift eastward toward dawn and generate bursts of whistler mode chorus waves which can propagate to the ground. The resulting "substorm chorus events" (SCEs) serve as a wave ground signature of substorm onsets alongside the more traditionally used ones based upon optical and magnetic field data. Although the phenomenon has been known for decades, it is only relatively recently that modern instrumentation and data processing techniques have allowed it to be used in a systematic way for studies of the substorm process, for example by *Smith et al.*, [*J. Geophys. Res.*, **102**, 2433, (1996)].

In this paper we review the characteristics of SCEs. We discuss recent statistical studies which exploit a data base of SCEs observed over many years at Halley station, Antarctica. We discuss the relationship between SCEs and other ground and space substorm signatures, both statistically and with reference to a number of specific substorm events. Finally, we describe a new ELF/VLF receiver network which is being established to obtain global SCE coverage by ensuring that whatever the UT of occurrence of a substorm, there will always be an observing station in the midnight to dawn local time sector where SCEs occur.

S12-22

PROPERTIES OF MAGNETOSPHERIC LINE RADIATION

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Magnetospheric line Radiation (MLR) events are relatively narrowband VLF signals ($\sim$ 30 Hz) that sometimes drift in frequency, and have been observed in both ground-based and satellite data sets. When first discovered in 1975 it was suggested that these events might be caused by power-line harmonic radiation (PLHR), generated from harmonics of the power transmission frequency (50 or 60 Hz) and radiated into the ionosphere and magnetosphere by long power lines. However, recent analysis of MLR events observed at Halley station, Antarctica (75°35' S, 26°33' W, $L \approx 4.3$) indicate that few, if any, MLR events are caused by or linked to PLHR. These studies have shown that MLR, while weak (mean rms amplitude of 11.5 fT), is present in a large proportion of ground-based observations. For example, it was found in one study that MLR was present in 7 % of the minute-long VLF recordings made at Halley over a two-week period. A later study using 4 months of data found that MLR occurrence rates could vary greatly within a given month, but the proportion of MLR present as part of the overall wave activity was roughly constant (10 – 13 %) throughout the year. MLR exhibits slow growth, relative frequency stability, and long lifetimes in comparison with other coherent whistler mode emissions. As yet the generation of MLR through a non-PLHR mechanism has not been addressed. The properties of MLR will be presented in order to stimulate discussion.

S12-23

VLF WAVE PHENOMENA IN THE INNER MAGNETOSPHERE OBSERVED ON MAGION-4 AND MAGION-5 SATELLITES

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MAGION-4 (58.7 kg) and MAGION-5 (68.5 kg) were launched as a part of the INTERBAL Mission into high elliptic orbits crossing the inner magnetosphere. Real-time telemetry mode allowed to record broadband VLF wave phenomena in a frequency band up to 22 kHz using magnetic and electric antennas. A number of interesting wave-phenomena occuring typically in the inner magnetosphere were observed including the LHR-associated phenomena like the LHR-noise bands, plasmaspheric emissions and magnetosphericaly reflected whistlers. MR-whistlers occurence region was found to be between L-shels 1.5 and 3.2. A large number of different types of the MR-whistler spectrogramms was detected and an effect of plasmapause position was found. The spectrogram observed strongly depends on the observation point location. LHR-noise bands represent a valuable tool foor monitoring the plasmapause position at altitudes above $1R_E$. Systematical observation of discrete plasmaspheric emissions (DPE) permits to check theoretical prediction that frequency band of DPE normalized to the equatorial gyrofrequency at the L-shell of observation should increase with increasing altitude of observation. DPE are suggested to originate from a quasi-electrostatic VLF-noise in the equatorial magnetosphere as a result of electron-cyclotron instability.

S12-24

A STATISTICAL SURVEY OF ELF/VLF WAVES OBSERVED BY AKEBONO

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Akebono was launched in 1989 into a semi-polar orbit with an altitude range between 300 km and 10,000 km, and is successfully operated for more than 11 years. Many kinds of plasma waves are observed using VLF/ELF instruments onboard the satellite. Using the long period observation datasets obtained by Akebono, statistical studies on the spatial and temporal distribution of electric and magnetic wave intensities in the magnetosphere are performed. As the generation/propagation mechanism of plasma waves in the magnetosphere reflects plasma environment which depends on many parameters such as solar activity, geomagnetic activity, altitude, latitude, local time, season etc., this global mapping is quite useful in deriving a dynamic structure of the magnetosphere.

Our statistical study clarified a lot of information on the energy distribution of VLF/ELF waves in the magnetosphere as described below. The active regions of the plasma waves are mainly located in the cusp, along the auroral oval, and along the plasmapause. The wave intensity becomes larger and the active region shifts toward lower latitude region, as Kp index becomes larger. The wave above 1 kHz in the vicinity of the plasmapause is dominantly chorus emission. The strongest chorus is observed in the dawn to noon sector. The higher frequency part of chorus distributes along the smaller L-value and in the earlier local time region. The projected map to the equatorial plane of the active region of the chorus is possibly correspond with the region of injected energetic electrons which are thought to be the energy source of the chorus. On the other hand, auroral hiss and broadband low frequency noise are predominantly observed in the auroral region. The activities of both wave modes depend on local time and season, and are quite consistent with the particle distributions in the auroral region.

S12-P01

MODIFIED MAXIMUM ENTROPY METHOD APPLIED TO Pc 3 MAGNETIC PULSATIONS AT LOW LATITUDE

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It has been known that Burg's maximum entropy technique in general is superior to a more conventional method of power spectral estimation. It has better resolution and it gives more realistic power spectral estimate for a short data record. The maximum entropy method, however, has some shortcomings, including a spectral line splitting and a shifting in frequency estimate. In particular, the frequency estimation of sinusoids in white noise has been shown to be very sensitive to the initial phase. In this report, it is confirmed that the shifting in frequency estimate can be reduced by using Hamming and Blackman window functions in the computation of a filter coefficient. Furthermore, the modified maximum entropy method is applied to estimate the frequency of Pc 3 pulsations observed at Yonezawa, Yamagata during morning hours.

S12-P02

STORM TIME LONG PERIOD (Pc 5-6) GEOMAGNETIC PULSATIONS UNDER STRONG SOLAR WIND DYNAMIC PRESSURE AND STRONG IMF MAGNETIC PRESSURE

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We analyzed the long period geomagnetic pulsations in the frequency range of $1-6$ mHz as a response to the interplanetary magnetic cloud storm on February 21, 1994. It was found that SSC at 09.01 UT as well as the initial phase of this storm were accompanied by strong solar wind dynamic pressure (P_d) and long period geomagnetic pulsations with maximum amplitudes near dayside polar cusp at the frequencies less than 2 mHz (ipcl-type). The dynamic spectra of these pulsations were similar to the spectra of the B_x IMF and P_d variations. We speculated that ground ipcl pulsations could be results of the interplanetary hydromagnetic waves penetrating into the Earth magnetosphere. Two interesting intervals of this magnetic storm were also analyzed: one – with very strong (up to $\sim$ 100 nPa) solar wind dynamic pressure ($\sim 13-14$ UT), and the second – with very high values of B IMF (up to $\sim$ 70 nT), that is, with strong magnetic pressure ($\sim$ 15 UT). During the first interval the maximum amplitude of the dayside $1-3$ mHz geomagnetic pulsations were observed near the polar cusp, however during the second interval the same frequency range geomagnetic pulsations were detected in the closed magnetosphere and could be interpreted as global cavity mode waves. The resonance nature Pc 5 pulsations of $3-5$ mHz have been observed during both intervals with maximum of the intensity in the local afternoon.

S12-P03

OBSERVATIONS OF Pi 2 PULSATIONS IN MID-LATITUDES

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Using geomagnetic pulsation observations obtained with induction magnetometers along the Norilsk meridian and from a network of mid-latitude observatories we investigate the excitation characteristics of Pi 2 pulsations in the noon sector of the magnetosphere and in mid-latitudes.

An additional (to nighttime) stable noon maximum was revealed in the diurnal distribution of the occurrence frequency of Pi 2 pulsations at the mid-latitude observatories, while the auroral stations recorded only a rare occurrence of Pi 2 around noon. The meridional intensity distribution of the daytime Pi 2 has its maximum at latitudes of magnetopause projection, whereas it occurs at auroral latitudes for nighttime Pi 2.

The development of the active phase of an auroral substorm is accompanied by a global excitation of Pi 2 pulsations at mid-latitudes with identical dynamic spectra. At the same time the source size of Pi 2 pulsations at high latitudes is limited longitudinally and appears to be determined by the zone of synchronous substorm development.

The onset time of maximum amplitude in Pi 2 pulsation intensifications (inferred from dynamic spectra) varied at different stations from a few fractions of a second to several tens of seconds, and these delays did not show any definite trend.

Experimental results are discussed in terms of the existence of a global mode in the Earth's plasmasphere as a plausible source of mid-latitude Pi 2 pulsations.

S12-P04

ELECTROMAGNETIC ION CYCLOTRON WAVES IN THE MAGNETOSPHERE-IONOSPHERE

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Electromagnetic ion cyclotron waves in the ELF/VLF range of frequencies are typically observed in auroral current regions and play an important role in heating ions in the topside ionosphere leading to ionospheric outflows of ions into the magnetosphere. In this paper we present a theory of nonlocal magnetosphere/ionosphere coupling mediated by ion cyclotron waves in which we solve the full wave equations for ion cyclotron waves generated near 5000 km which propagate earthward. The model includes multiple ion species (H^+, He^+, O^+ and NO^+) and collisions (ion-neutral, electron-neutral, and electron-ion) with profiles consistent with observation. The model also resolves the cyclotron resonance locations and includes important mode conversion processes associated with the ion-ion hybrid resonances. The wave solutions obtained from the model provide: (1) resolution to discrepancies between theoretical predictions based on ray-tracing and spacecraft/rocket comparisons and (2) understanding of the relative roles of ion cyclotron heating and ionospheric dissipation for ion cyclotron waves.

S12-P05

CHARACTERISTIC RESULTS FROM STORM-TIME Pc 5 PULSATIONS

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A globally coherent Pc 5 geomagnetic pulsation event that occurred during $11 - 13$h UT on March 24,1991 has been analyzed using three component geomagnetic data from 38 worldwide observatories. The spectra have indicated latitudinally and longitudinally invariant period at 600 s. Consistent with the field line resonance model, the amplitudes and polarization behaviours exhibited the characteristics across the auroral oval. Also, the senses of polarization have indicated the expected inter-hemispherical reversal in H-D plane. A noteworthy fact is the significant enhancement of the pulsation amplitudes near the magnetic equator (Equatorial Electrojet-EEJ), where they are comparable to those that are observed at the Auroral Electrojet-AEJ region. This further confirms the near simultaneous transmission of magnetospheric electric fields from AEJ to EEJ, through the ionosphere of the intermediate region. There is a distinct difference in the amplitude and sense of polarization at mid-latitudes across the dawn/dusk terminator. All these are found to be associated with the Y-component of the geomagnetic field changes attributable, again, to the sources in the ionosphere at the dawn/dusk time.

Similar coherent Pc 5 pulsations are observed in association with the SC storm of 6th April 2000. During the recovery phase of the storm on 7th April, regular periodic variations,apparently in two wave packets, one between 04 and 10 UT and the other between 12 and 17 UT have been noticed. The spectra of these events have indicated dominating frequencies around 1.73 mHz (580 s period) in the first and around 1.89 to 2.05 mHz (529 to 488 s periods) in the later interval at a low latitude station, Alibag, in the Indian sector. Comparing the waveform and polarization characteristics of pulsations from Indian and Japanese sectors, effects of dusk terminator are quantified. This combined with the features noted for March 24, 1991 event are utilised to emphasise the role of the ionosphere in the transmission of the energy.

S12-P06

MODULATION OF RADIO WAVES AT LOCAL FIELD LINE RESONANCE FREQUENCIES

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Ionospheric scintillations of radio wave frequencies at equatorial latitudes are generated by the presence of electron density irregularities. These irregularities are fiels aligned and can provide energy all along the field line. It was felt that non-local field aligned oscillations like the local field line resonance could be easily excited under these conditions. The typical field line resonance periodicity at equatorial latitude for night time ranged from $20 - 25$ sec. Systematic presence of $20 - 25$ sec peak in the scintillations recorded on 250 MHz radio beacon suggest the modulation of radio waves through field line resonance.

S12-P07

ON THE POLARIZATION STRUCTURE OF MID-LATITUDE Pc 3-4 PULSATIONS DERIVED FROM THEIR ELECTRIC FIELD SIGNATURE

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The polarization changes at sunrise and noon hours are well-documented by ULF geomagnetic field measurements. Our purpose is to analyze Pc 3-4 geoelectric pulsations of at least one month duration, recorded at a mid-latitude station (Nagycenk, Hungary). In addition to the spectral analysis, a polarization study of the geoelectric pulsations under quiet and disturbed conditions is completed. In our preliminary analysis, we have observed sunrise effects occasionally and they do not exist regularly. We shall further examine the geoelectric field signature of both the sunrise and noon changes of the ULF wave polarization. We intend to continue our polarization analysis to study also the electric signature of the FLR polarization reversal at noon. The diurnal features of Pc 3-4 geoelectric pulsation characteristics are sorted according to the geomagnetic activity conditions. A model based on the electric/magnetic field asymmetry in the polarization changes through the ionosphere-atmosphere system has been suggested. Influences from the atmosphere-litosphere system are additionally accounted for. Subsequently, other appropriate models are applied for a comparison with our ULF geoelectric data. The observed features of the electric and magnetic field polarization at sunrise indicates that the geomagnetic pulsations in the selected frequency ranges are partly of compressional (magnetosonic) type.

S12-P08

ENERGETICS OF ULF WAVES IN THE MAGNETO- AND IONO-SPHERES

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How much energy of Pc 3 and Pc 5 ULF waves does transmit across the magnetopause, and then propagate into the magnetosphere? In order to clarify this problem we have examined Poynting fluxes of Pc 3 and Pc 5 ULF waves observed near the dayside magnetopause by using the magnetic and electric field data obtained by the GEOTAIL satellite. The results reveal that energy fluxes of Pc 3 and Pc 5 waves have been estimated as 10 to 50 nW/m^2, and 1 to 50 $\mu W/m^2$, respectively. If the wave energy could be finally dissipated in the ionosphere, the energy would be about 10^{12} J/h for Pc 3, and $10^{13} - 10^{14}$ J/h for Pc 5, respectively. Although the dissipation would be one or two orders less than the substorm energy, the wave energy continuously penetrates into the magnetosphere. Therefore, ULF wave energy would play an important role for energetics in the magnetosphere and the ionosphere.

S12-P09

IONOSPHERIC OBSERVATIONS OF Pc 5 WAVES GENERATED AT THE INNER EDGE OF THE LOW LATITUDE BOUNDARY LAYER

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Dayside ULF Pc 5 waves observed in a localized latitudinal region near the dayside convection reversal boundary by the Greenland array of magnetometers form a distinct class of high latitude magnetic pulsation which can be identified from the spatial characteristics of the disturbance field. For these pulsations, the horizontal magnetic perturbation vectors measured by an array of stations point radially toward or away from a point, and this point appears to move across the array in the tailward direction. Such signatures are the result of mesoscale vortical Hall currents in the ionosphere associated with a field-aligned current along a tailward moving flux tube. The source of these waves appears to be the east-west convection shear at the inner edge of the low latitude boundary layer which is produced by IMF B_y reconnection. Case study and statistical results will be presented

S12-P10

COMPARISON OF AURORAL LUMINOSITY VARIATION AND MULTIPLE Pi 2 PULSATIONS AT A SUBSTORM ONSET USING 1-SEC RESOLUTION GROUND-BASED DATA

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All-sky auroral data from an auroral zone station at Kotzebue, Alaska, and magnetic field data from both high- and low-latitude stations were used to demonstrate the relations between auroral luminosity variation and multiple Pi 2 magnetic pulsations during a substorm onset on September 12, 1994. Both data were sampled with a time resolution of 1-sec. Four Pi 2 wave packets can be identified in the magnetic field data for 09:45 – 10:10 UT, which is around the end of growth phase and start of expansion phase. Initial analysis using 30-sec resolution auroral data shows that each Pi 2 wave packet has good correspondence to each small-scale auroral brightening and poleward expansion. This fact indicates that Kotzebue was located near the onset region of auroral substorm. In the presentation, we report further results using 1-sec resolution auroral data to discuss onset timings of magnetic and auroral substorms and to discuss driving mechanism of Pi 2 pulsations by field-aligned current oscillation (which will be identified as auroral luminosity oscillation).

S12-P11

CHARACTERISTICS OF ULF WAVES AT DIFFERENT LOCAL TIMES

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ULF waves in the Pc 5 frequency range are studied based on Polar and ground-based observations. The wave events studied were observed for different local times in the 65 to 75 degrees invariant latitude region. Magnetic and electric field measurements are used to characterize the waves, *e.g.* polarization of the wave fields, the phase speed from the B/E ratio, phase differences between the field components, Poynting flux and relation to higher frequencies. The frequencies of the waves were in agreement with what would be expected for fundamental field line resonance. Ground-based data near the footprint were used to analyze the influence of the waves on the ionosphere. Magnetic signatures were observed on the ground near the footprint of the field lines related to the ULF waves. Solar wind data were analyzed to obtain the energy input from the Sun. The modes of the waves will be discussed as well as the possible source of the waves.

S12-P12

Pc 1 WAVES AND IONOSPHERIC ALFVÉN RESONATOR: GENERATION OR FILTRATION

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We analyze the vertical profile of Pc 1 wave fields produced in the ionosphere by a plane Alfvén wave incident from above due to magnetospheric Pc 1 emissions. The problem of interest is whether the reflection of these emissions from the ionosphere has a significant influence on their generation in the magnetosphere. Our analysis shows that data from low-orbiting satellites can provide a valuable information to answer this question. In particular, we show that the ratio of the electric and magnetic fields varies strongly with frequency due to the influence of the ionospheric Alfvén resonator (IAR). A most remarkable difference in this ratio exists for frequencies corresponding to either maximum or minimum ionospheric reflection. Therefore, an analysis of satellite data on electric and magnetic fields of Pc 1 emissions detected in the ionosphere (at the same field line as their magnetospheric source) allows to make a certain conclusion whether these waves are generated at conditions of maximum or minimum ionospheric reflection. Comparison of our theoretical result with a recent statistical analysis of Pc 1 pearls recorded onboard DE 2 satellite suggests that these waves were generated near maximum of the reflection coefficient. This implies that reflection from the ionosphere could play a significant role in formation of these Pc 1 emissions.

S12-P13

STANDING WAVE STRUCTURE AND SUBSTORM LOCAL DIPOLARIZATION OBSERVED BY CRRES

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We examined electric and magnetic field variations during substorm 6.03.91 by CRRES near outer boundary of the Earth's electron radiation belt. The CRRES observed one oscillation of the E_y and B_z components with guasi-period of ~ 50 s. The electric field oscillation leads the magnetic oscillation by 90° in phase, indicating on even mode standing wave structure. The flux of energetic particles changes antiphase to the compressional magnetic component B_z. This oscillation may be a coupled shear Alfvén-slow magnetosonic mode. The quasi-period and amplitude of E field oscillation are increasing when the local magnetic field reconfiguration occurs and the plasma sheet has expanded. *Holter et al.* [1995] interpreted similar oscillation events with periods of about $45 - 65$ s as the result of the ballooning instability [*Miura et al.*, 1989]. Besides the CRRES observed a large (~ 36 mV/m peak) impulsive meridional electric field E_r with a short time ~ 40 s duration. This impulse correlates with stepwise change of B_y component of magnetic field and has an induction nature. We suppose that analysed electric and magnetic variations associated with the substorm expansion. Rapid temporal development of the ballooning - interchange instability can lead to the nonlinear process of magnetic field reconfiguration, which will in turn induce a electric field. We gratefully acknowledge N. Maynard for electric field data, H. Singer for magnetic data, and A. Korth for energetic particle data from the CRRES.

S12-P14

Pc 1 PROPAGATION CHARACTERISTICS DERIVED FROM TWO-STATION OBSERVATIONS

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Two methods were applied to determine signal direction of arrival for structured Pc 1 emissions detected at two space-apart observatories. One of the methods is a well-known technique of plotting the polarization ellipse and hunting the direction of its main axis. The other method is a new one. It uses information on the vertical component of the wave field to restore the direction of the wave surface normal.

Distance between the observatories was about four thousand kilometers. 22 Pc 1 events observed simultaneously at two stations were analyzed. Amplitude, spectral, and polarization characteristics were determined for the data analyzed. Cross-correlation technique was used to determine apparent group velocity and sign of delay in time of signal arrival. All but one of the events demonstrated a positive lag which means that signal propagated from east to west. Apparent group velocity of signal propagation ranging from 276 to 9782 km/s were observed.

Comparison between two methods of direction-of-arrival location shows a substantial difference of direction estimates obtained by the polarization ellipse method and by the wave surface normal technique. It implies that a geological inhomogeneous structure gives a considerable contribution to orientation of wave field components at two sites involved.

S12-P15

PROTON PRECIPITATION RELATED TO Pc 1 PULSATIONS

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Using the low-altitude NOAA satellite data we for the first time found and described a pattern of proton precipitation, characteristics of which closely correspond with those for the Pc 1 pulsations. The pattern is characterised by a burst of both precipitating and locally trapped energetic protons within the zone of anisotropic fluxes. The bursts are localised ($\sim$1 degree of invariant latitude); most of events are found within the range of $61-67$ degrees of invariant latitude; they appear mainly during the recovery phase of geomagnetic storms, and their occurrence rate is maximal at the day side. The comparison of these specific proton bursts detected in the ionosphere with Pc 1s observed in Sodankyla Geophysical Observatory, Finland has been performed for the whole year 1996. We found that intense Pc 1s on the ground can be observed at any MLT distance from the satellite detecting the precipitation burst, but the probability of Pc 1 observations strongly decreases with increase of the distance. The frequency of the ground Pc 1 decreases with the increase of the proton burst latitude. These findings lend to support the idea that Pc 1 pulsations are the result of ion-cyclotron instability of the ring current ions.

S12-P16

AUTOMATIC DETECTION OF Pi 2 EVENTS AND THE ONSET TIME BY USING WAVELET TRANSFORM

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We have developed an algorithm for automatic detection of the onset of Pi 2 pulsations by using the wavelet transform. It is found that the Cauchy wavelet with proper parameters has a time resolution higher than that of the Gabor wavelet, and is suitable for the detection of Pi 2 onset. It is revealed that the time of power peak of the Cauchy wavelet transform is given within one to three minutes after the onset of Pi 2. This time lag has been automatically compensated in the present algorithm, and it is shown that the onset time of almost all Pi 2 events can be determined with an accuracy of one minute.

Another algorithm for automatic detection of Pi 2 events have been developed by applying the Gabor wavelet. It is revealed that power of the Gabor transform integrated in the frequency range of Pi 2 is well correlated with Pi 2 activity. Furthermore, by taking account of differences of the power and duration between Pi 2 and Pc 3 pulsations, we have developed a method that can distinguish Pi 2 and Pc 3 in the same frequency range. It is successfully demonstrated that more than 95 % of Pi 2 events can be automatically detected by using the present algorithm.

S12-P17

OCCURRENCE OF ULF WAVES IN THE NEAR-EARTH MAGNETOSPHERE: POLAR EFI OBSERVATIONS

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We investigate field-line resonances in the inner magnetosphere, using electric field observations of the Polar satellite in 1996 – 1999. Due to its high-inclination orbit, the Polar satellite can detect the radial extent of the field-line resonances in two local time sectors at 18-hour intervals; all local time sectors are covered in 3 months. Field-line resonances are frequently observed over a large range of L shells so that the resonance period increases with L, which requires the existence of a broad-band source. The solar wind conditions are investigated during these events. A specific source of field-line resonances is a storm sudden commencement (SSC) which has occurred approximately 80 times during the lifetime of the Polar satellite. However, all the SSCs are not associated with ULF waves although the spacecraft has been in a favorable position in the inner magnetosphere. We discuss the conditions required for the occurrence of ULF waves after SSCs.

S12-P18

NUMERICAL RESULTS FOR AN ALFVÉN SWEEP-MASER MODEL OF Pc 1 PEARLS

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We study a self-consistent model for generation of Pc 1 pearl emissions, known as Alfvén sweep maser (ASM) model. It is based on nonlinear coupling between the magnetospheric and ionospheric resonators for Alfvén waves, The coupling mechanism is related to the variation of the reflection coefficient R of Pc 1 emissions from the ionosphere under the influence of energetic protons precipitated into the ionospheres due to generation of these Pc 1 waves in the magnetosphere. We present numerical simulations of the ASM equations taking into account both the nonlinear feedback described above and group velocity dispersion of Alfvén waves. They prove the establishment of a bouncing Pc 1 wave packet (pearl) which depends on the ionospheric and magnetospheric parameters. We show that a pearl-like regime of wave generation is possible in a wide range of parameters; in particular, properties of conjugate ionospheres may be different. The ionospheric reflection substantially influences formation of pearls even if the ionospheric reflection coefficient is small, $R \sim 0.1$. We discuss some peculiarities in satellite and ground-based observations of pearls on the basis of our numerical results.

S12-P19

GROUND MAGNETIC PERTURBATIONS ASSOCIATED WITH THE STANDING ALFVÉN OSCILLATION IN THE MAGNETOSPHERE-IONOSPHERE SYSTEM

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Ground magnetic perturbations associated with the standing Alfvén oscillation in the magnetosphere-ionosphere coupled system are studied by using a trapezoid-shape magnetosphere model, in which the main magnetic field is assumed to be directed straight but be inclined to the ionosphere with the height-integrated Pedersen and Hall conductivities (S_P and S_H, respectively). It is found that the ground magnetic perturbation is proportional to S_H/S_P under a static condition ($S_P > S_H$) and is inversely proportional to S_H under an inductive condition ($S_P < S_H$). Under the inductive condition, the ionospheric electric field becomes small due to the inductive field and thus the magnetic field perturbation is shielded. This shield is more effective for the higher harmonic mode of the standing oscillation because the inductive field also becomes larger for the higher frequency regime. Next, the realistic ionospheric and magnetospheric parameters based on the IGRF and IRI are used in order to examine the behavior of the standing oscillation. The result reveals that the ground magnetic perturbation associated with the fundamental standing Alfvén oscillation is almost static. On the contrary, those of the higher harmonic ones are inductive because of its higher frequency. It is also found that the north-south asymmetry of the ground magnetic perturbations depends not only on the L-value but also the magnetic longitude due to the non-uniformity of the ionospheric and magnetic field condition. Our model explains the seasonal dependence of the north-south asymmetry of geomagnetic pulsation signal intensity.

S12-P20

SOURCES OF Pc 3 ENERGY AT HIGH LATITUDES

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Band-limited daytime Pc 3 pulsations present one of the most common features of the high-latitude ULF spectra. While their generation is undoubtedly related to the ion-cyclotron instability upstream from the bow shock, the waves' propagation down to the high latitudes is still puzzling. New information about possible propagation mechanisms can be found from statistical studies of Pc 3 seasonal-diurnal variations and the dependence on interplanetary plasma parameters. However, recent investigations have also shown the importance of the broadband noise-like background spectral component, which may distort the measured characteristics of Pc 3 waves. Until now the relative contribution of this noise to the total Pc 3 energy has not been fully established. In this work we attempt to address two related issues: (a) the ability to extract the noise component from the average ULF spectrum and (b) study of the band-limited and noise-like components with respect to their possible generation and propagation mechanisms. In the studies we have used three years of induction magnetometer data from Australian Antarctic stations and interplanetary plasma parameters measured by the WIND satellite.

S12-P21

THE GENERATION AND PROPAGATION OF Pc 3-4 (10 – 50 mHz) WAVES IN THE HIGH LATITUDE MAGNETOSPHERE

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It is now generally accepted that at low latitudes ($L <$ or equal to 3), Pc 3-4 waves are the result of standing shear Alfvén mode field line resonances. This phenomenon extends into high latitudes ($L > 5$), but longer field lines move the resonance frequency into the Pc 5 (1 – 10 mHz) range. Broadband Pc 3-4 waves at high latitudes have been investigated by several workers but the generation mechanism for narrowband Pc 3-4 remains unclear. Using IMAGE magnetometer data we have conducted an investigation of high latitude Pc 3-4 events for January and March 1998. We examined amplitude, cross-phase and coherence as a function of latitude and longitude, and determined the propagation velocity and coherence length of each event. Antarctic magnetometer data provided information on conjugate point phase and polarization of these events. WIND satellite data provided information on IMF strength and cone angle. Preliminary results suggest that these pulsations are due to compressional mode waves generated by the upstream ion-cyclotron resonance mechanism, and propagating inward through the magnetosphere.

S12-P22

HF RADAR OBSERVATIONS OF ULF WAVES NEAR THE PLASMAPAUSE

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An important application of HF radars is the measurement of ULF wave fields in the ionosphere. Many authors have previously discussed the observation and properties of ULF waves in the high latitude ionosphere. These are usually interpreted in terms of standing eigenoscillations of field lines, or global cavity modes. The TIGER HF radar scans lower latitudes than other SuperDARN radars and provides the opportunity to examine ionospheric perturbations in the vicinity of the plasmapause. We review the ground and radar signatures of ULF pulsations in this region and present examples from the TIGER data set.

S12-P23

ONE DIMENSIONAL MODEL FOR ULF WAVE PROPAGATION IN THE IONOSPHERE

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The importance of knowing wave structure of ULF waves as they propagate through the ionosphere has been shown in various studies in radar data. The Doppler shifts which are observed in radar data are affected by the ULF wave and its affect on ionospheric motions. We present a model study of ULF wave structures in the ionosphere, appropriate to this problem. We model the ULF wave as an electromagnetic wave and solve for the electric and magnetic field perturbations due the wave as a function of height. The ionospheric conductivity is represented by a complex dielectric tensor that varies with height. In particular, we consider Shear or Compressional Alfvén Modes as well as a mixture of these two modes, incident on the top boundary of the ionosphere. In this study the inclination of the magnetic field or dip angle is a free parameter, allowing us to consider any magnetic latitude.

S12-P24

HF DOPPLER OSCILLATIONS DUE TO MIXED ULF WAVE MODES

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The propagation of HF (3 – 30 MHz) signals via the ionosphere has been studied since the advent of radio. At these frequencies the properties of the ionospheric plasma cause the signal to be continually refracted which makes long distance communications possible yet very dependent on ionospheric parameters. The propagation path in the ionosphere is determined by the signal frequency and the mediums refractive index. Any time variation in the refractive index will also vary the propagation path, giving rise to a Doppler frequency shift of the HF signal. In this paper, changes in the refractive index due to ULF (1 – 100 mHz) waves incident from the top side ionosphere are examined. ULF energy in the cold plasma of the magnetosphere exists in two wave modes known as the fast magnetohydrodynamic (MHD) and shear Alfvén wave modes. In the 1 – 100 mHz band, FLR (purely shear Alfvén modes) occupy a small section of the spectrum with most of the energy in the fast mode or some mix of the two modes. In this paper we shall examine the effect of a mixture of these two modes on the Doppler shift seen in HF radar via the use of a simple numerical model. The results of the modeling will be compared with observed Doppler shifts recorded in low latitude HF signal data.

S12-P25

EFFECT OF 2D SPATIAL INTEGRATION ON Pc 5 ULF AZIMUTHAL WAVENUMBERS OBSERVED ON THE GROUND

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Investigation of the spatial structure of the ULF waves is important for understanding their generation and propagation mechanisms in the magnetosphere. The most common technique for these studies relies on the ground-based magnetometer arrays. However, the ground structure of the ULF wave could be quite different from that in the ionosphere as measured by HF-VHF radars. Besides the well-known rotation of the wave's polarization ellipse due to the ionospheric Hall currents, the amplitude and phase on the ground may be distorted by a spatial integration effect due to the broad field of view of the magnetometers.

This work is concerned with the effect of the spatial integration on the azimuthal wave numbers of the high-latitude Pc 5 pulsations, which determine the propagation properties of the wave at the magnetopause. We used Saskatoon SuperDARN data to restore horizontal distributions of frequency, phase and amplitude of Pc 5 pulsations, which were also observed by the CANOPUS magnetometer array. Using a simple model we attempt to show that the observed discrepancies between ionospheric and ground azimuthal wavenumbers could be caused by the spatial integration effects in the magnetometer data. Even though it is known that the ionosphere smears the spatial structure of ULF waves, most studies have focused on the latitudinal aspects associated with field line resonances. The modelling presented shows that (i) the total observed horizontal wave structure is modified by the ionosphere and (ii) both the incident wave amplitude and phase spatial structure contribute to the ground magnetometer signal.

S12-P26

ROLE OF IONOSPHERIC HALL EFFECT ON THE ENERGY BALANCE IN THE MAGNETOSPHERE-IONOSPHERE COUPLED SYSTEM

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The role of ionospheric Hall effect on the energy balance in the magnetosphere-ionosphere (M-I) coupled system through the field-aligned current (FAC) is discussed. It is well known that the ionospheric Hall current can not be dissipated or worked on the external system ($\boldsymbol{J}_{HALL} \cdot \boldsymbol{E} = 0$). However, it is also true that the ionospheric rotational Hall current excited by the incident FAC, and it generates the Poynting fluxes of poloidal type magnetic field to the magnetosphere and atmosphere. From a viewpoint of energy conservation law, it seems that there are some ambiguities above two contexts. By dividing the total currents concerning the M-I coupling into the divergent and rotational current systems, we clear up the role of ionospheric Hall effect in the energy balance between ionospheric Joule dissipation and Poynting flux of wave fields. We confirm that the net works between these current systems done by the Hall effect are cancelled out each other, but the rotational current system spend a energy of FAC (divergent current) through the divergent Hall current. The relation ($\boldsymbol{J}_{HALL} \cdot \boldsymbol{E} = 0$) in total current system fairly means the relation ($\boldsymbol{J}_{HALL} \cdot \boldsymbol{E}$ in divergent system + $\boldsymbol{J}_{HALL} \cdot \boldsymbol{E}$ in rotational system = 0). Put another way, to build up the large scale steady Hall current in the ionosphere, during of its growing stage (inductive process), the finite divergent Hall current pump up the energy of FAC system into the rotational Hall current. Our new theory clarify, when the ionospheric rotational current system or electrojet current system are growing up, how they get their growing energy from the FAC system, and what is the carrier of such energy transfer. A new theory can be easily applied to the formation process of auroral electrojet and equatorial electrojet current systems.

S12-P27

Pi 2 SOURCE REGION DEDUCED FROM THE CPMN DATA

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In order to investigate the occurrence region of Pi 2 and its propagation mechanisms in the magnetosphere, ground magnetometer data observed at CPMN stations was analyzed. Magnetic energy of Pi 2s was defined as $(dH)^2+(dD)^2$, and calculated for Pi 2 events observed at four stations located in high-latitude region. The times when the amplitude of magnetic energy becomes maximum and the ratio of the maximum amplitude were compared among stations. The results were as follows. Pi 2s observed at Kotel'nyy (KTN: $MLAT$ = 69.94, $MLON$ = 201.02) located higher latitude region toward the auroral oval reached the maximum amplitude earlier ($\sim$ 20 s) than those at lower latitude station Tixie (TIK: $MLAT$ = 65.67, $MLON$ = 196.88), though the amplitudes were smaller at KTN than at TIK on average. The Ultra Violet Image (UVI) data obtained by Polar satellite indicated that when auroral oval located equatorward to KTN, magnetic energy of Pi 2 observed at KTN tend to reach maximum earlier than TIK. Longitudinal characteristics of Pi 2 magnetic energy derived by longitudinally separated stations TIK, Chokurdakh (CHD: $MLAT$ = 64.67, $MLON$ = 212.12) and Kotzebue (KOT: $MLAT$ = 64.52, $MLON$ = 249.72) indicated the existence of longitudinal center of Pi 2 propagation. The propagation center was estimated $\sim$ 22.5 MLT. Eastward (westward) of the center, Pi 2 magnetic energy exhibited the eastward (westward) propagation. MLT dependence of relative maximum time and amplitude of Pi 2 magnetic energy measured from the propagation center were derived empirically. Combining observational results and numerical estimation of Alfvén transit time, which was calculated from a point in the magnetosphere to the ground station, it was deduced that Pi 2 was generated around 9 R_E and 22.5 MLT on the equatorial plane in the magnetotail.

S12-P28

RELATIONSHIP BETWEEN LOW-LATITUDE Pi 2 PULSATIONS AND MAGNETOSPHERIC SUBSTORM ONSETS

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At the onset of magnetospheric substorms, Pi 2 magnetic pulsations with periods of 40 – 150 s occur globally in the magnetosphere. The source of nighttime Pi 2 pulsations is generally believed to be a sudden change in the magnetospheric configuration or convection during the substorm expansion phase. This change is caused by earthward plasma flows from the reconnection region and/or a sudden generation of field-aligned currents (FACs) between the polar ionosphere and the magnetospheric plasmasheet in association with the disruption of cross-tail currents. The formation of the substorm current wedge (SCW) also causes the magnetic bay variations at mid- and low latitudes.

Because the Circum-pan Pacific Magnetometer Network (CPMN) have been constructed along the 210° magnetic meridian and the magnetic equator, it is now possible to investigate global characteristics of Pi 2 pulsations and the one-to-one correspondence between Pi 2s and substorm onsets, and then examine if the source of night-time Pi 2 pulsations also triggers magnetospheric substorms or not.

In order to re-examine relationships between low-latitude Pi 2 pulsations and magnetospheric substorms onsets, we have analyzed 119 Pi 2 events observed at the midnight sector of 22:30 – 23:30 LT at the CPMN stations. It is found that at least 5 events of the first onset of multiple-onset Pi 2s occurred without a magnetic bay (or with a bay of smaller than 0.4 nT magnitude) at Guam. This observation suggests a possibility that the source of night-side Pi 2s, for example, oscillatory earthward flows (*Kepko et al.*, 2000) and/or sudden generation of FACs between the polar ionosphere and the plasmasheet, sometimes directly drive low-latitude Pi 2 pulsations without enhancement of the magnetic bays at mid- and low latitudes.

S12-P29

EFFECT OF LOW LATITUDE IONOSPHERE ON ULF WAVES

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Assuming the ionosphere to be a thin metallic sheet separating the magnetosphere and the ground, we can show that the polarisation of an ULF wave detected on the ground is related to that at the magnetosphere. This relationship depends on the ionospheric conductivities as well as on the latitude of the ground station. We have applied this theory to some observed Pc 3-4 micropulsation signals detected on the low latitude ground stations in INDIAN region.

S12-P30

CHARACTERISTIC OF GLOBAL Pc 1 ACTIVITIES AFTER MAGNETIC STORMS

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Electromagnetic ion cyclotron waves, Pc 1 waves, are considered to be generated and observed on the ground when active conditions are provided for magnetospheric plasma by adiabatic actions, by injections of fresh hot plasma and by specially organized quenching processes such as to produce pearl type emissions. Analyzing global network data acquired at multiple points (10 – 30 locations) in the northern polar region (STEP Polar Network, http://hpep3.eps.s.u-tokyo.ac.jp) we show that Pc 1 regions activated with the three manners in the above are separately observed in local time and in the couse of initial, main, and recovery phases of magnetic storms. Each of the three types is observed in the initial phase, in the early-main phase, and through the recovery phase of magnetic storms, respectively, within limited spans of local time; the dayside sector, the evening to pre-midnight sector, and the pre-midnight to morning sector. On space-time evolution of such Pc 1 regions a remarkable tendency is found that the third type of Pc 1 regions exhibits to drift from the mid-night sector toward the morning sector in a few days from the early recovery phase indicating it partly subjected to the co-rotation force. Dynamic behaviors of the Pc 1 regions are compared for cases of selected magnetic storms during STEP and S-RAMP periods and are discussed in terms of dynamics of hot and cold plasma region in magnetic storms.

S12-P31

EFFECTS OF THE IONOSPHERIC CONDITIONS ON THE ULF PULSATIONS OBSERVED AT GEOMAGNETIC CONJUGATE PAIR STATIONS

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Since the boundary conditions of field-line oscillations are predominantly determined by the ionospheric conditions, magnetic pulsations observed at conjugate pairs should be affected by the ionospheric condition both of northern and southern hemispheres. To detect the effect of ionospheric conditions on magnetic pulsations, we statistically analyzed the geomagnetic data from the conjugate pair stations of the Circum-pan Pacific Magnetometer Network (CPMN) along the 210 degrees magnetic meridian. The conjugate pair stations are located at Kotzebue (KOT) in Alaska and Macquarie island (MCQ) in Australia. They are in the high latitudinal region ($L = 5.4$). High coherent (> 0.7) Pc pulsations between KOT and MCQ can be regarded to be a resonance oscillation. Then their power calculated by the FFT (fast Fourier transform) method are compared mutually, and some of asymmetric natures of their power between northern and southern hemispheres are found to be brought into sharp relief. The variations of northern/southern asymmetry of ULF power ratio are follows, 1. Generally, power of magnetic pulsations at KOT tends to be stronger than that of at MCQ (offset). 2. This trend becomes weak in high frequency band. 3. In summer hemisphere, power of magnetic pulsations becomes weak compared with that of winter hemisphere (shielding effect). 4. This trend becomes large in high frequency band. These frequency dependencies of the power imply the 'inductive' effect of ionosphere on the magnetic pulsations. The divergent Hall current can cause shielding effect on ULF amplitudes in suitable condition of ionosphere, and especially it has great influence in higher frequency band (*Yoshikawa and Itonaga*, 2000). In this report, we will show variations of northern/southern asymmetry of ULF power ratio, and try to interpret these natures by using the inductive ionosphere model.

S12-P32

PLASMA AND MAGNETIC FIELD EVOLUTION NEAR GEOSYNCHRONOUS ORBIT IN THE MIDNIGHT SECTOR AT AURORAL BREAKUP

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An auroral precipitation event recorded during 05:00 – 05:20 UT of 17 Jan., 1986 by all-sky camera at Shamattawa (Canada; 55.9°N, 92.1°W in geographical coordinates) during Global Aurora Dynamic Campaign (GADC) was examined by comparing it with the magnetic field data as observed by geosynchronous satellites, GOES 5 (74.8°W) and GOES 6 (108°W), and also with ground magnetometer at dip-equator, Huancayo, in the midnight sector. From the analysis of this event, following results were obtained:

1. Location of the auroral breakup projected in magnetosphere was in between and slightly tailward of the two satellites, GOES 5 and 6.
2. The field displacement for D component (positive eastward in the dipole coordinates) at two satellites oscillated out of phase during the auroral breakup.

These results suggest that there may exist enhancement of plasma pressure near geosynchronous altitude in the midnight sector as the auroral breakup was initiated, and auroral particles precipitate along field line. Based on this model, we examine what happens at such a region when a plasma pressure is increased suddenly by performing a simple model calculation.

S12-P33

REGULARITIES OF AURORAL STREAMER FORMATION AND THEIR RELATIONSHIP TO IMPULSIVE MAGNETIC FIELD VARIATIONS

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In all 48 nights of auroral TV registration at Tixie for 1994 – 1999 have been analyzed. During that period about 200 N-S aurora stretched along the meridian or auroral streamers have been registered and their characteristics and formation conditions have been firstly studied. It has been found that auroral streamers are mainly observed at late-evening hours (21 – 23 LT), they are generated at discrete aurora oval latitudes ($L > 7-8$) and are predominantly drifted with the velocity of $1-5$ km/s south-westward before the midnight, southward at midnight hours and south-eastward after the midnight. Auroral streamers can penetrate into the diffuse auroral zone during the drift process and reach the equatorial boundary ($L = 4$) of it. During the auroral streamer generation the equatorial diffuse aurora boundary also moves southward but it is more slowly by a factor $5-20$. Auroral streamers are often observed in $3-8$ min after the substorm onsets but also registered during the convection disturbance periods. It is shown that auroral streamers are accompanied by impulsive magnetic field variations with periods of $\sim 5-15$ min where the amplitude of D and Z components exceeded noticeable the amplitude of H component. These variations have been called by us as "late-evening Ps 6 pulsations". Ionospheric currents responsible for these pulsations are localized in auroral streamer region and predominantly flow to the north (south) for auroral streamers drifting westward (eastward). It has been established that generation processes of auroral streamers and torch-like structures can be interrelated. It is shown that during the convection disturbances the formation of auroral streamers in the premidnight sector and torches at night-morning side has been taken place. $10-20$ min before the appearance of torches the equatorward drift of discrete auroral arcs and southward propagation of auroral streamers has been observed.

S12-P34

STATISTICAL STUDY OF GLOBAL CONCURRENT OCCURRENCE OF Pi 2 PULSATIONS IN THE EQUATORIAL REGION

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At high and mid latitudes, Pi 2 pulsations are generally observable in limited local times in the nightside. With decreasing of latitude, the region of Pi 2 pulsations can be observed extends longitudinally. Several studies have examined the global concurrent occurrence of equatorial Pi 2 pulsations. In the equatorial region, Pi 2 pulsations can be observed concurrently in the dayside and nightside. However, statistical evaluations are not yet clarified. We statistically analyzed magnetic field data from the Equatorial Magnetometer Network in order to examine global concurrent occurrence of Pi 2 pulsations in the equatorial region. Five equatorial stations (GUA(Geographic Longitude = 145), PRD(81), MOK(14), ALC(−44), ANC(−77)) of the Equatorial Magnetometer Network are used here. These stations are globally separated 222 degrees in longitude. 97 Pi 2's are found by using of magnetic data of ALC during the period from October 10, 1993 to December 13, 1993. It is confirmed by using of magnetic data of three low latitude stations (MSR, HAR, VIC) that these pulsations are associated with bay variations in the nightside low latitude region. Cross correlation coefficients between ALC and the other stations are obtained. It is found that, cross correlation coefficients of 85 percent of Pi 2 events are higher than 0.7 and time differences of 71 percent of Pi 2 events are within 15 seconds among the separated equatorial stations. The global concurrent occurrence of Pi 2 pulsations is confirmed statistically in the equatorial region. In this region, wave forms of dayside Pi 2 pulsations are similar to those in the nightside.

S12-P35

IONOSPHERIC CONVECTION ASSOCIATED WITH THE LONG-PERIOD GEOMAGNETIC PULSATION

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A global geomagnetic pulsation (period of about 14 min) under a condition of southward IMF (about −10 nT) was observed during an interval of 2214 to 2309 UT on February 28, 1998. The geomagnetic pulsation appeared coherently at the dayside auroral and equatorial latitudes, characterized by an equatorial enhancement. The equivalent ionospheric convection deduced from magnetic fluctuations consists of quasi-stationary twin current vortices centered around 15 MLT near 72 degs magnetic latitude. SuperDARN observed duskside portion of a large-scale convection vortex centered around 15.5 MLT near 77 degs magnetic latitude for the southward IMF. During this event, quasi-periodic fluctuations in the solar wind dynamic pressure ($1-2$ nPa) excited compressional mode waves in the magnetosphere, as observed by magnetometers at geosynchronous orbits and on the low-latitudes ground. In conclusion, a quasi-steady ionospheric convection vortex centered around 72 degs is due to field aligned currents originating in the dayside inner magnetosphere, excited by fluctuations in the solar wind dynamic pressure rather than the southward IMF.

S12-P36

GEOMAGNETIC MICROPULSATION MEASUREMENTS AT THE FERRAZ BRAZILIAN ANTARCTIC STATION

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This work shows some results on the occurrence of geomagnetic micropulsations as measured at the Ferraz Brazilian Antarctic Station – EACF (62°S, 58.4°W), which is situated near the Southern border of the South Atlantic Magnetic Anomaly. The micropulsation events were chosen from the geomagnetic data observed during 1993 – 1994 and 1997 – 1999. A high sensitivity (better than 0.1 nT) ring core three-axis (H, D, Z) fluxgate magnetometer measured geomagnetic variations in the DC to 4 mHz range, at each 2-min interval, and a pair (X, Y) of magnetic coils measured variations in the 10 mHz to 2.5 Hz range at each 0.2 s. The results obtained from the data analysis show the occurrence of Pc 1, Pc 2, Pc 3, Pc 4 and Pc 5 micropulsations in the geomagnetic spectra observed at Ferraz. The results are discussed taking account the interaction between the earth's magnetic field and the solar wind, as well as the dynamics of the radiation belts energetic particles. The low level of the man made electromagnetic noise makes the Antarctic region one of the best natural geophysical laboratories for the study of geomagnetic micropulsations.
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S12-P37

PROTON AND ELECTRON HEATING BY RADIALLY PROPAGATING FAST MAGNETOSONIC WAVES

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We investigate the growth, propagation, and decay of fast magnetosonic waves in the Earth's magnetosphere which are believed to contribute to proton heating up to energies of a few hundred eV near the magnetic equator. We use the HOTRAY code to calculate the path integrated growth and decay of the waves between $L = 2 - 7$. Waves are excited near the harmonics of the proton gyrofrequency by a proton ring distribution at energies of the order of 10 keV. Strong Landau damping by plasmasheet electrons confines wave propagation to within a few degrees of the magnetic equator. The waves are absorbed by Doppler shifted cyclotron resonance with superthermal protons resulting in pitch angle scattering and heating of superthermal protons transverse to the ambient magnetic field. The amount of absorption, and hence transverse proton heating, increases significantly as the thermal proton temperature is increased up to 100 eV suggesting a feedback process. Ray tracing shows that transverse heating of the thermal proton distribution is likely to occur just outside the plasmapause in regions where the Alfvén speed is large and comparable to the proton ring velocity at corresponding ring current energies. Since the flux associated with proton ring distributions is significantly enhanced during magnetic storms at ring current energies, the amplitude of fast magnetosonic waves should also be enhanced. We suggest that the excitation of fast magnetosonic waves and subsequent energy transfer into thermal protons and plasmasheet electrons could provide an additional energy loss process for ring current decay.

S12-P38

ELECTRON PITCH ANGLE DIFFUSION AND THE FORMATION OF PANCAKE DISTRIBUTIONS

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Observations show that highly anisotropic pitch angle distributions known as pancakes are associated with electrostatic electron cyclotron harmonic (ECH) waves and whistler mode waves. Both wave modes may contribute to the formation of pancakes by pitch angle scattering and loss, and to the diffuse aurora, but the dominant wave mode has not yet been established. Here we present a detailed analysis of the particle distribution function measured by CRRES during an event where both wave types and pancake distributions were observed simultaneously. We construct a model of the distribution function and solve the linear dispersion relation to find the unstable wave modes. We find that the resulting unstable whistler mode wave spectrum contains a spectral slot or drop out in the growth rates at frequencies near half the electron gyrofrequency. By using the HOTRAY ray tracing code we calculate the path integrated gain for both ECH and whistler mode waves. The ECH waves propagate across the magnetic field while the whistler mode waves propagate along the field, but both types of waves only grow substantially within a few degrees of the magnetic equator. We find that the spectral slot is still present in the whistler mode wave spectrum even when propagation in a non-homogeneous medium is considered and that the gain for ECH waves is significantly greater than that for whistler mode waves. By calculating the diffusion rates for ECH waves it is shown that ECH waves can produce the pancake distributions at energies below a few keV, as observed. We suggest that if the ECH waves, driven by the loss cone, are sufficiently strong the resulting the pitch angle diffusion changes the stability of the whistler mode waves leading to the spectral gap in the whistler mode wave spectrum. We suggest this as a possible mechanism for producing double banded chorus emissions.

S12-P39

SELF-CONSISTENT APPROACH TO TRIGGERED VLF EMISSIONS: PHASE AND NONLINEAR EFFECTS

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We generalize a self-consistent analytical theory of triggered VLF emissions [1, 2] with account of phase and nonlinear effects. The self-consistency comprises calculation of parameters of an electron beam which is produced by an initial quasi-monochromatic whistler wave packet and further generates the triggered signal. The phase modulation of the electron beam determines the initial amplitude of the triggered whistler-wave signal via the so-called antenna effect [3]. This signal is amplified via cyclotron beam-plasma interactions. The dynamic frequency spectrum of triggered emissions and the maximum amplification are determined by the second-order cyclotron resonance effects. These effects should be calculated with account of the nonlinear change of the electron beam velocity due to the loss of the beam energy upon generation of the secondary waves. Some results of such calculations are presented in this report.

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THE SHORT PERIODIC MAGNETOSPHERIC VLF EMISSIONS

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In this report, the problem of short periodic VLF emissions with typical periods $2 - 6$ seconds is examined in more detail. We study the self-consistent problem of interaction between the electromagnetic VLF emission and the electron radiation belts without common simplifications because the electromagnetic pulse duration can be comparable with the variation time of the distribution function. We take into account both the linear dispersion in the nonuniform magnetospheric resonator and the cyclotron amplification variation during the pulse as a result of the wave-particle interaction. If the energetic electron distribution function has an appropriate form, then the consolidation of emission in packets reduces the dissipation of electromagnetic energy, and these processes can give a gain in energy. Consequently, the effective saturation of dissipation leads to rather short electromagnetic pulses which pass between conjugate ionospheric regions without shape variations. The average frequency of the emission changes during the pulse. The cause of the excitation of short periodic VLF emissions is connected with the compensation of the dispersion signal transformation and the quasilinear evolution of the cyclotron instability increment as a result of the evolution of the distribution function during the electromagnetic pulse. The separated spectral elements are similar to whistlers. However, in contrast with multihop whistlers, they do not have the typical spectral form evolution from one signal to another.

S12-P41

GENERATION OF ALFVÉNIC TURBULENCE BY BROADBAND PLASMA WAVES

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Broadband plasma waves, having frequencies from below lower hybrid to electron plasma frequency and above, have been observed by many satellites on the auroral and cusp field lines. The amplitude of the electric field of these waves can be from a few tens to hundreds of mV/m. These large amplitude waves can decay into kinetic Alfvén waves (KAWs) by parametric process. We consider the auroral plasma to consist of cold electrons, hot electrons and ions. The high frequency pump wave is taken to be electron-acoustic wave (EAW). We drive a nonlinear dispersion relation for the three-wave interaction process involving electron-acoustic (pump wave) and kinetic Alfvén wave and another electron acoustic wave as daughter waves, using multifluid equations. The observed amplitudes of the EAWs are found to exceed the threshold required to excite the KAWs. This mechanism may be a plausible candidate for the generation of KAWs in the auroral and cusp regions.

S12-P42

GEOTAIL OBSERVATION OF CHORUS EMISSIONS IN THE MAGNETOSPHERE

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Various types of ELF/VLF chorus and discrete emissions have been observed by the GEOTAIL spacecraft in the magnetosphere. The Plasma Wave Instrument (PWI) can measure overall spectra as well as electromagnetic wave forms of the emissions, which give their detailed spectra and propagation characteristics such as wave normal and Poynting directions. Statistical analysis of the emissions show that most of their propagation characteristics are consistent with those observed by past spacecraft studies, but several interesting features are also found such as certain intensity variation with wave normal angles. On the other hand, energetic electrons in cyclotron resonance with the emissions have also been measured with high energy and time resolutions by the Low Energy Particle (LEP), which would give experimental evidence of yet unclarified wave-particle interaction involved in chorus generation and propagation. Detailed examination of measured three-dimensional velocity distributions of the resonant electrons suggests that their pitch angle anisotropy is too small to linearly generate simultaneously observed chorus emissions. This could be caused by pitch-angle diffusion of resonant electrons due to the generated chorus emissions, which reduces the initially unstable anisotropy within a time scale (< 1 sec) short enough compared with the time resolution of particle measurements (several tens of seconds).

We will present detailed comparison between wave and particle data, as well as particle simulation results of chorus generation, and discuss if there is any evidence of wave-particle interaction found in the data to investigate generation and propagation mechanisms of the chorus emissions.

S12-P43

WHISTLER OBSERVATIONS AT GREAT WALL STATION: ACTIVITIES WITH GEOMAGNETIC STORMS

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Based on the extensive observations at the Great Wall station in Antarctica (located at the island George King where $L = 2.1$), the activities of whistlers during geomagnetic storms in quiet and disturbance days have been analysed by statistics. To uncover the state on the path of whistlers propagate, we have developed a relative occurrence rate by subtracting the 20 days running average of the occurrence. Though the occurrence rate of whistlers varies with the local seasons, the relative occurrence rate developed by us has rather good correlation with geomagnetic storms. It is suggested that the propagation of whistlers is affected by the geomagnetic activities. To investigate the detail relation between the whistler occurrence and magnetic storms, we selected some rather large and isolated magnetic storms and take the superposition of the total occurrence in every hour according the relative time to the main phase of each storm of ten magnetic storms. It is proved that there is an obvious time delay about 3 days from geomagnetic activity peak to whistler activity peak. The occurrence rate of whistlers reduces first when the magnetic storms begin and then increase to more than usual in the recovery phase of storms up to maxim and keep it for $5 - 15$ hours. It suggested that the suddenly change of geomagnetic field could damage the original whistler duct during the storm. During the recovery phase, plasma particle may consist up much more new duct than the period before the storm.

S12-P44

STUDY ON ELECTROSTATIC WAVES NEAR THE LOWER-HYBRID FREQUENCY IN THE LOBE REGION OF EARTH'S MAGNETOTAIL OBSERVED BY GEOTAIL

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We observed electrostatic waves in the lobe region of earthfs magnetotail by the GEOTAIL spacecraft. Frequency of these electrostatic waves is near the lower-hybrid frequency. The waves are observed in the transition region between the lobe region to the plasma sheet boundary layer. Until now, some of the lower-hybrid frequency waves in the plasma sheet boundary layer were studied but the lower-hybrid frequency waves in the lobe region are not investigated in detail. Electric field vectors of the waves are perpendicular to the local magnetic field. Generation of these waves does not correlate with density nor magnetic field gradients. The waves are observed with an electron beam, which is parallel to the local magnetic field, and velocity of the electron beam is from 15000 km/s to 20000 km/s. These waves are often observed with steady ion flow that is perpendicular to the local magnetic field. We show results of analysis of these waves.

S12-P45

FULL WAVE ANALYSIS OF MULTI-SITE VLF OBSERVATIONS IN ANTARCTICA

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Natural and artificial VLF waves observed in Antarctica have long been used to examine a magnetospheric ducted transmission mechanism. Intensity and bearing of natural VLF waves, such as whistler and hiss, are used to determine duct exit regions and duct output power, and to estimate their amplitude at the magnetospheric equator, which is responsible for precipitation loss of radiation belt energetic electrons through wave-particle interaction. On the other hand, by receiving signals from known VLF transmitters located in the northern hemisphere, we can evaluate the "magnetospheric gain" (amplification or absorption in the magnetosphere) of whistler mode signals, which in turn gives information on energetic electron flux in the duct. Such studies, however, have been relied on rather simple models of Earth-ionosphere VLF propagation and attenuation from the duct exit regions to the receiving sites on the ground.

In this work, we apply a full wave analysis to more quantitatively evaluate the VLF propagation characteristics through the ionosphere as well as the Earth-ionosphere waveguide. With the ionospheric model based on actual rocket experiments and the IRI models, the full wave analysis rigorously computes VLF field and polarization distributions over a (1000 km $\times$ 1000 km) horizontal area on the ground for an arbitrary VLF power distribution at the duct exit. Computed results are used to interpret multi-site observations of hiss (2 kHz) at Halley and of a VLF transmitter signal (21.4 kHz) at Faraday, Antarctica. Comparing computed field distributions with the observed ones, we will present possible duct exit regions, duct output power, and the "magnetospheric gain" of those VLF waves, and discuss the mechanism of ducted VLF transmission to polar regions.

S12-P46

MAGNETOSPHERIC LION ROARS

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The Equator-S magnetometer is very sensitive and has a sampling rate of normally 128 Hz. The high sampling rate allows for the first time detection of ELF waves between the ion cyclotron and the lower hybrid frequencies in the equatorial dawn-side magnetosphere. The characteristics of these waves are virtually identical to the so-called lion roars typically seen at the bottom of the magnetic troughs of magnetosheath mirror waves. The magnetospheric lion roars are near-monochromatic packets of electron whistler waves lasting for a few wave cycles only, typically 0.2 s. They are right-hand circularly polarized waves with typical amplitudes of 0.5 nT at around one tenth of the electron gyrofrequency. The cone angle between wave vector and ambient field is nearly always smaller than 1 deg.

S13-01

PARALLEL ELECTRIC FIELDS IN DISCRETE ARCS

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We present a large-scale model of the parallel electric fields in the upward current region of the aurora. The model, called the "Transition Layer Model", applies to intense, discrete arcs. It is based on 1-D spatial, 2-D velocity static Vlasov simulations and on observations from the Fast Auroral Snapshot (FAST) satellite. The model depicts three regions along the magnetic field that are separated by two transition layers which contain the majority of the parallel electric fields. The low-altitude region is dominated by ionospheric plasma, the high- altitude region by plasma sheet populations. The region in between, the auroral cavity, is dominated by ionospheric ions and magnetospheric electrons. The lower-altitude layer, called the "electron transition layer", separates the auroral cavity from the ionosphere. The higher-altitude layer, called the "ion transition layer", separates the auroral cavity from the plasma sheet-dominated magnetosphere. The current-voltage properties closely follow the Knight relation. The model is supported by FAST, Polar and DE observations.

S13-02

SOLITARY WAVES AT HIGH AND LOW ALTITUDES ON AURORAL AND CUSP FIELD LINES

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Large amplitude solitary waves have been observed in several distinct regions of the Earth's magnetosphere, including the auroral zone, the high altitude cusp, at $\sim 5-9\ R_E$, and the plasma sheet boundary, at $\sim 4-7\ R_E$. In the low altitude auroral zone case, two different types have been identified. In the upward current regions, the observed solitary waves are negative potential structures moving upward at speeds intermediate between the hydrogen and oxygen beam speeds (a few hundred km/s). In contrast, solitary waves in the downward current regions move upward at several thousand km/s, are positive potential structures, and are associated with upward electron beams. This evidence suggests an electron rather than an ion mode. Preliminary results of studies of large amplitude solitary waves in the high altitude regions, including velocities $>$ 1000 km/s, also seem to be consistent with an electron mode. Analysis of amplitude versus parallel spatial width of solitary waves in the downward current auroral zone has indicated that these faster structures are more likely a BGK mode rather than a soliton. Within a related family of solitary waves, the amplitude scales as the fourth power of the width for BGK modes while it scales inversely to the square of the width for acoustic modes. Such analysis, therefore, is extremely useful in distinguishing between BGK hole modes and acoustic solitons. We will describe the methodology and results of a statistical study of solitary wave characteristics in the upward current auroral zone, the plasma sheet boundary, and the high altitude cusp. The results will be compared with expectations from theory, and compared to ongoing simulations. Characteristics studied include amplitude versus parallel spatial width, parallel and perpendicular extent, and structure velocity.

S13-03

PARTICLE AND FIELD OBSERVATIONS IN THE SOURCE REGION OF AURORAL KILOMETRIC RADIATION: IMPLICATIONS FOR GENERATION MECHANISMS

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The Fast Auroral Snapshot Explorer (FAST) has provided high resolution data of unprecedented detail from within the auroral acceleration region. This region is also the source of auroral kilometric radiation (AKR). The FAST data have shown that the cyclotron maser instability is the primary mechanism for generating AKR, but with the instability being driven by the accelerated and mirroring electrons, rather than the upgoing loss-cone. Evidence favoring this mechanism include the following observations. Energetic electrons dominate the electron density, and the resultant plasma frequency is orders of magnitude smaller than the electron gyro-frequency. The electron distribution shows the characteristic "horseshoe" shape associated with parallel electric field acceleration and magnetic mirroring. The wave frequency descends below the local cold-electron gyro-frequency. The wave electric and magnetic fields are consistent with a perpendicularly propagating X-mode wave. Thus FAST has firmly established the principal instability mechanism and the free energy source for AKR. Outstanding issues, which FAST data are being used to address, include the causes of "fine structure" within AKR, the preferred direction of propagation for the waves, along or across the density cavity, and the escape of the radiation from the source region.

S13-04

AURORAL PLASMA TURBULENCE AND THE CAUSE OF AKR FINE STRUCTURE

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The electron cyclotron maser and electron acoustic instabilities do not develop independently but share the available energy stored in the electron distribution. Electron acoustic waves excited in the AKR source region in presence of a very dilute cool electron background are shown to lead to a strong fine structuring of the AKR radiation. Using high time and frequency resolution measurements of the FAST wave tracker we demonstrate that AKR consist of a large number of elementary radiation events which we interpret as traveling electron acoustic cavitons or electron holes. Estimates of the propagation velocity of these structures are in good agreement with theory. Power estimates show that elementary events contribute significantly to the total AKR emission. Elementary radiation structures may sometimes be reflected from the acceleration potential or be trapped in larger structures like ion acoustic waves and by following their time variation allow to infer about the meso-scale motion of the AKR source region.

S13-05

ON MODELS FOR THE FINE STRUCTURES OF BROADBAND PLASMA WAVES OBSERVED ON THE AURORAL FIELD LINES

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Broadband electrostatic noise (BEN), with frequencies extending from the local lower hybrid frequency up to the local electron plasma frequency (or even above), has been observed in several regions of the Earth's magnetosphere, *e.g.*, in the magnetopause boundary layer, polar cap boundary layer, magnetotail, on cusp and auroral field lines and in the magnetosheath. These broadband plasma wave emissions are correlated with electron and ion beams or ion conics. Recent exciting high time resolution results coming from Geotail, Viking, Polar and FAST show that broadband plasma wave emissions consist of bipolar and monopolar solitary structures. The observed short-scale solitary electric potential structures have been explained either as BGK phase-space electron holes or as solitons (*e.g.*, ion acoustic, electron acoustic, whistler, etc.). It is likely that the observed spectrum of the electrostatic component is due to 2D lower hybrid solitons. Various models put forward to explain the fine structures of the broadband plasma waves observed on the auroral/cusp field lines will be discussed. These solitary structures may play fundamental role in auroral acceleration/heating processes.

S13-06

AKR RELATED EMISSIONS

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AKR (Auroral Kilometric Radiation) has been known more than 25 years and studied a lot. This paper treats two AKR related emissions, Auroral Myriametric Radiation (AMR) and Low frequency (LF) busts.

LF busts, also called isotropic terrestrial kilometric radiation (ITKR), were found by *Steinberg et al.* Their frequencies are between 30 and 100 kHz and often associated with AKR. The lowest frequency of AKR sometimes becomes 30 kHz and AKR is spin modulated. On the other hand, LF bursts are not spin modulated and isotropic. They are proposed to be back scattered in the interplanetary (IP) medium far down the tail magnetosheath and lobes ducted after radiation is emitted near the Earth. The present paper compares intensities of LF bursts observed by Geotail, POLAR, and WIND satellites in order to examine their source and propagation mechanisms.

AMR was found by he GEOTAIL Plasma Wave Instrument (PWI). Its frequency range is about $1-30$ kHz similar to the trapped continuum radiation and its occurrence shows a good correlation with AKR. Ray tracing is performed for L-O mode waves radiated just above the local plasma frequency in the auroral plasma cavity. The waves are guided in the cavity, propagated far from the earth, and observed as AMR. In the source region, these guided waves are observed by the DE 1 satellite and reported as the trapped L-O mode waves within the cavity. This confirms that the source location of AMR is similar to that of AKR. Characteristics of AMR are discussed.

S13-07

WEAKLY RELATIVISTIC PLASMA CAVITY AS A SOURCE OF AURORAL KILOMETRIC RADIATION

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We consider a plasma cavity which is filled by weakly relativistic electrons and surrounded by cold plasma as a source of Auroral Kilometric Radiation. We show that under certain conditions there exist unstable eigen-modes of such a resonator. We describe these modes in two limiting cases, *i.e.*, when the resonator has sharp boundaries, and when the transition between the two plasmas is smooth. We estimate the characteristic growth rates and the limit of stability for these modes.

S13-08

GENERATION OF AURORAL KILOMETRIC RADIATION BY ELECTRON HORSESHOE DISTRIBUTIONS

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High time resolution of rocket and satellite electron distribution functions within the source region of Auroral Kilometric Radiation (AKR) display a characteristic crescent shaped or horseshoe distribution. Such distribution functions are created by a field aligned electron beam moving into an increasing magnetic field, conservations of the first adiabatic invariant causes an increase of their pitch angle. This produces a broad region on the distribution function where there is a positive slope on the velocity distribution function, and is a possible source of free energy leading to radio wave emission by a cyclotron maser instability, which is more efficient that the conventional loss-cone maser instability. We examine the stability of these electron horseshoe distribution functions for x-mode radiation at the electron cyclotron frequency propagating perpendicular to the magnetic field. We will present analytical and 3-D particle in cell simulations.

S13-09

ELECTRON BEAM INSTABILITIES IN A NONUNIFORM SYSTEM: GENERATION OF LANGMUIR WAVES AND SOLITARY WAVES

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In recent spacecraft observations, coherent microscale electrostatic structures such as Langmuir waves and electrostatic solitary waves are observed in the auroral zone, the plasma sheet boundary layer and other regions of the magnetosphere where we can find high energy electrons forming an electron beam. Langmuir waves and solitary waves are generated as a result of coherent nonlinear trapping of electrons as found in bump-on-tail, bi-stream and Buneman instabilities. We performed a series of particle simulations in a large one-dimensional system where an electron beam is injected locally from one of the open boundaries. Depending on the thermal velocity of the background electrons, spatial and temporal behavior of the electron beam differs greatly, resulting either Langmuir waves or electrostatic solitary waves. The Langmuir waves are strongly localized in space near the source region. They are also excited at the front portion of the passing electron beam, but their duration time is relatively short. On the other hand the solitary waves are generated continuously from the source region of the electron beam, and they can propagate over a long distance along the ambient magnetic field. The frequent observation of such solitary waves in the auroral zone indicates that the local plasma with energetic electrons is close to a state of marginal stability.

S13-10

POLAR S/C OBSERVATIONS OF INTENSE ELECTRIC FIELDS AND ALFVÉNIC POYNTING FLUX IN THE PLASMA SHEET AT 4 – 6 R_E ALTITUDES: RELATION TO AURORAL PARTICLE ACCELERATION

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We review recent observations from the Polar spacecraft which demonstrate that there are periods of intense net earthward Alfvénic Poynting flux (> 1 erg/cm^2/s) along the magnetic field direction at altitudes of $4 - 6$ R_E in the plasmasheet boundary layer. If this Poynting flux is mapped down converging magnetic field lines to altitudes of 100 km the extrapolated energy flux is > 100 ergs/cm^2/s. The associated electric fields have amplitudes > 100 mV/m, the magnetic fields are transverse ($10-40$ nT) with $E/B \sim 1$ Alfvén velocity. We present evidence that these Alfvénic structures are among the most intense contributors to energy transfer in the plasma sheet and that they can provide sufficient energy flux to power all particle energization processes in the auroral acceleration region. These Alfvén waves are observed when the spacecraft is conjugate to UV images of intense auroral structures associated with auroral electron beams with estimated energy fluxes of > 25 ergs/cm^2/s over spatial scales of ~ 1 degree.

High time resolution electric and magnetic field measurements indicate the Alfvén waves are often striated into numerous intense smaller scale kinetic Alfvén wave structures with amplitudes ranging to greater than 300 mV/m with durations in the spacecraft frame of < 1 s and E/B ratios of $2 - 5$ Alfvén velocities. Analysis of the data indicates the structures have perpendicular scale sizes of $3 - 50$ km (an electron intertial length = 10 km) and that they have parallel electric fields which can accelerate particles parallel to the magnetic field to energies of about 3 keV. There is direct experimental evidence for field aligned electron acceleration and heating of to energies of several keV.

S13-11

SOURCE AND RELEASE OF ENERGY IN AURORAL PARTICLE ACCELERATION

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Auroral particle acceleration requires an energy flux flowing into the acceleration region and the subsequent development of non-dissipative parallel electric fields. Thus, in order to understand the dynamics of auroral particle acceleration, the mechanisms by which electromagnetic energy, momentum and angular momentum are carried to the auroral acceleration region must be comprehensively considered. Energy can flow into the auroral zone either in the form of Poynting flux or particle energy flux, with the former being the predominant mechanism in most cases. This Poynting flux may be related to a steady-state current system or to the propagation of shear Alfvén waves. This incoming energy is stored in the kinetic energy and the magnetic energy that are related to the velocity field and magnetic field fluctuations in the perpendicular direction, respectively. The important question is how this energy related to the perpendicular dynamics is transferred into the energy required for the development and maintenance of a non-dissipative parallel electric field.

It has been noted that the parallel displacement current, while numerically small, describes the evolution of the parallel electric field. A set of equations including the displacement current has been derived, which describe the relationship between the temporal and spatial derivatives of the total field-aligned current, including the displacement current, and the perpendicular vortex motion. Based on energy considerations and these dynamical equations, we propose that nonlinear interaction of incident and reflected shear mode wave packets in the auroral acceleration region can release the kinetic and magnetic energy carried by the wave packets. Either solitary waves or a net parallel electric field may be formed, depending on the polarizations of the interacting wave packets. We will point out the differences between the energy transfer in the steady state case and in the Alfvén wave model. We will emphasize the importance of the localized breakdown of the frozen-in condition in energy release and redistribution.

S13-12

GEOTAIL, POLAR, AND WAVE ISTP IN SITU AND REMOTE OBSERVATIONS OF AURORAL PLASMA AND RADIO WAVE EMISSIONS RELATED TO STORMS AND SUBSTORMS

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The GEOTAIL and POLAR Plasma Wave (PWI) and WIND Radio Science (WAVES) experiments on the ISTP spacecraft detect in situ and remotely auroral plasma wave phenomena related to geomagnetic storms and substorms. Enhanced auroral kilometric radiation (AKR) intensity and bandwidth are well known to be related to increased geomagnetic activity and indicate expanding source regions. Low frequency (LF) bursts are a part of AKR often observed during strong and frequently isolated substorms detected by ground magnetometer networks and auroral brightenings observed by various imaging experiments. Many of the LF bursts occur related to highly geoeffective CME events observed by SOHO. Magnetic field dipolarization and field-aligned currents and large injections of protons and electrons are observed during LF burst events. Direction finding results from single and multiple spacecraft show that spacecraft within the magnetosphere detect a compact source for the portion of the LF burst below the magnetosheath plasma frequency while those outside detect a large extended source. Continuum storms, enhanced escaping terrestrial continuum radiation, and kilometric continuum also accompany substorms at delays ranging from only a few minutes to many tens of minutes.

S13-13

CONNECTION BETWEEN AURORAL AND PLASMA SHEET DYNAMICS

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The energetic electrons responsible for auroral luminosity come from various sources that extend from ionospheric heights to the distant regions of the magnetosphere. Studying the aurora can reveal important information on the way these sources operate. In this talk, we discuss new experimental findings recently made which are relevant to furthering understanding of the cause of aurorae and substorms. A variety of auroral features has been observed by our UVI instrument on Polar coincidentally with particles and fields measured in the ionosphere and the near-earth plasma sheet. These correlated data indicate that a common plasma sheet process may be triggering auroral precipitation. This process occurs during magnetic quiet as well as more disturbed times. It operates over a range of spatial scales, from localized small auroral pseudobreakup events to the larger global substorm events. The process is active throughout the near-earth plasma sheet region and it accelerates electrons to several hundred keV and ions to a few MeV energies. This is accompanied in the ionosphere by the brightening of the aurora and AKR emission. The accompanying magnetic variations fluctuate close to the ion gyrofrequency and phase space distributions show multicomponent plasma and nongyrotropic features. These observations are not part of any existing models and would require new theories and kinetic models to explain them.

S13-14

AKEBONO OBSERVATION OF AURORAL ENERGIZATION PRECESSES OF IONOSPHERIC PARTICLES

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Energy flow from the magnetosphere into the auroral ionosphere causes energization of ionospheric ions and electrons through various processes. Low-energy particle observation on polar-orbiting AKEBONO satellite has often detected these energized particles of ionospheric origin flowing upward over the auroral zone. We focus on the perpendicular energization of ions (*i.e.*, ion conics) below 10000 km on the dayside in this presentation.

More energetic ion conics are observed at higher altitude. The ion conics with a cone angle around 60° are most energetic at an altitude. Elevated conics are generally more energetic than standard conics, and appear above 6000 km while standard conics appear at lower altitude. These observation results are most likely to be attributed to the effect of height-integrated energization of ions. The conclusion is also supported by a modeling of observed occurrence frequency of ion conics as a function of altitude and cone angle. Both the observations and modeling also suggest that the ion convection strongly influences ion energization on the dayside. We found that IMF (Interplanetary Magnetic Field) controls the dayside ion energization. Ion conics are more energetic and more frequently observed when B_z is negative and the magnitude of B_y is large. The polarity of B_y controls the asymmetrical MLT distribution of ion conics around the local noon, which is attributed to a possible effect of convection pattern on dayside ion energization.

S13-15

REMOTE ANALYSIS OF DAYSIDE ION HEATING PROCESSES USING CONJUGATE SATELLITE AND RADAR MEASUREMENTS

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The dayside cusp/cleft region has been identified as a major source of ionospheric ions for the Earth's magnetosphere. Observations from rockets and low-altitude satellites show that ions are heated perpendicularly to the Earth's magnetic field. They provide direct crossings of the ion heating regions and enable to analyze ion heating processes associated to various types of waves (*e.g.*, ion cyclotron, lower hybrid waves), but their measurements are restricted to a narrow altitude range.

Due to the magnetic mirror force, the heated ions form outflows which are detected by satellites orbiting at higher altitudes over the dayside auroral and polar regions. Such outflows are characterized by regular energy dispersions due to the magnetospheric convection which separates ions depending on their time of flights from their source region. Therefore, low-energy ion measurements performed at high altitude contain information about ion heating over a broad range of altitudes, and enable a remote spatial analysis of the heating region.

In this paper, we will show how observations from low- and high-altitude satellites can be related to each other using convection measurements from the SuperDARN chain of groundbased radars. Such observations enable to analyze both the spatial extent and the physical nature of ion heating processes in the dayside.

S13-16

THE DYNAMIC CUSP AURORA AND ASSOCIATED PLASMA CONVECTION/ MAGNETIC ACTIVITY: RESPONSES TO NORTHWARD AND SOUTHWARD TURNINGS OF THE IMF

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Characteristic features of the time-history of the ionospheric responses in the cusp region to southward and northward turnings of the IMF are reported. The study is based on the combination of the following observational parameters: 1) optical aurora, 2) particle precipitation, 3) plasma convection, and 4) ground magnetic deflections. Among the southward turning responses are: 1) equatorward boundary intensifications/poleward moving auroral forms, 2) equatorward- and longitudinal expansions of the cusp emission band, 3) activation of merging convection cells, as observed locally by radars and by magnetometers covering the 0900 – 1500 MLT sector. Northward turning responses are: 1) poleward boundary intensifications, 2) poleward expansions, 3) latitudinal widenings of the cusp emission band, excitation of polar cap arcs emanating from the cusp band, 4) excitation of lobe cell convection. The continuous ground based observations may be used to infer the time variability of magnetopause reconnection processes located equatorward and poleward of the cusp.

S13-P01

ELECTROSTATIC ION CYCLOTRON WAVES IN A MULTI-COMPONENT AURORAL PLASMA

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Nonlinear propagation of electrostatic ion cyclotron waves at an angle to the ambient magnetic field in a homogeneous magnetized multi-component plasma consisting of cold ion beam and warm ions and cold and hot electrons is studied. From the basic set of equations, a nonlinear evolution equation for electrostatic ion cyclotron waves is derived using the travelling-wave approximation. The nonlinear wave equation is solved numerically for the plasma parameters encountered in the auroral acceleration region. The computed wave forms, amplitudes and velocities of the nonlinear electrostatic ion cyclotron structures are compared with the satellite observations. The results may have implication for the generation of parallel electric fields in the auroral region.

S13-P02

GENERATION AND PROPAGATION OF CYCLOTRON MASER EMISSIONS IN THE AKR SOURCE CAVITY

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The Fast Auroral SnapshoT (FAST) satellite has provided clear evidence that the primary auroral electron distribution in the AKR source cavity is modified into a "horseshoe" or "shell" structure due to the combined effects of an accelerating electric field and magnetic mirroring and that the source region is nearly void of low-energy electrons. We use $2\frac{1}{2}$-D particle-in-cell simulation models in the x,z (meriodinal) and x,y planes (where y is in the longitudinal direction and z is along the magnetic field) to study the generation and propagation of cyclotron maser emissions within the AKR source cavity. In the driven (x,z) simulations, the maser radiation builds up very rapidly with decreasing altitude and reaches peak intensity at only $5-6$ km below the injection point. The corresponding bandwidth is about 0.002 times the electron cyclotron frequency, comparable to but somewhat larger than the observed bandwidth of a few hundred Hertz. In the x,y simulations, the radiation component propagating normal to the cavity boundary leaks out by means of mode conversion to the Z mode, except for primary electron energies of about 2 keV and below. Thus as the radiation refracts upward from the localized source region, it will be increasingly dominated by the component propagating tangentially to the boundary. As suggested by *Louarn and Le Queau* [1996], this component can directly couple to the free space X mode when the cyclotron frequency has decreased sufficiently so that the external X mode cutoff becomes smaller than the wave frequency. The results of the simulations will be compared with FAST observations of the AKR wave polarization.

S13-P03

BGK ELECTRON HOLES AND FIELD-ALIGNED CURRENTS

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We have studied the properties of BGK phase space electron holes (EH) and in this talk we present new results including the existence of an upper limit of the EH velocity with respect to ions due to an instability. In view of the fact that it takes 80 ms to construct an electron distribution on FAST and that during this interval more than 100 solitary waves may be observed, we have simulated the expected electron distributions that would result and have compared them to those obtained by the FAST spacecraft. Our results are consistent with the interpretation that the distributions FAST obtained are time aliased BGK EH and the ambient thermalized electron distributions. Our analysis also sheds light on the role of the electrostatic waves and their connection to field-aligned currents. It is suggested that BGK EH is one way to sustain the field-aligned currents in the auroral downward current region.

S13-P04

UNDERSTANDING PARALLEL ELECTRIC FIELDS AND WAVE-PARTICLE INTERACTIONS IN THE AURORAL ZONE USING SIMULATIONS AND FAST/ POLAR OBSERVATIONS

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Quasi-static parallel electric fields formed in the primary current region of the auroral zone can accelerate electrons towards the Earth and ions away from the Earth. These accelerated electron and ion beams can lead to the generation of plasma waves that modify the resident plasma populations through various types of wave-particle interactions. The FAST and Polar satellites are well situated to examine these processes in the low and high altitude auroral regions, respectively. Data from these satellites will be used in conjunction with particle simulations to understand how the parallel electric fields are formed, as well as how wave-particle interactions effect plasma transport in the region.

S13-P05

AURORAL ALFVÉNIC SHOCKS IN THE IONOSPHERE-MAGNETOSPHERE COUPLING: MULTI-SCALE WAVE STRUCTURES

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Intense, small-scale, oppositely directed, paired perpendicular electric fields (dubbed electrostatic shocks) and longitudinal currents are known to be associated with the low-altitude particle acceleration and discrete auroral arcs. We show that these structures can be described in terms of the eigenmodes of the magnetospheric convection stratification instability, if the capture of kinetic Alfvén waves by a transverse wave-guide, a density cavity across B, is included. Resulting Alfvénic-shock-structures effectively accelerate ions across the magnetic field producing ion conics and narrow density dips. Inside these dips, the necessary condition for strong double layer formation is easily fulfilled resulting in either a narrow field-aligned electron finger at the edge of the corresponding arc or a black aurora, depending upon whether it is the region of the upward or downward Birkeland current. The distribution of accelerated ions turns out to be unstable with respect to lower hybrid waves growth. Therefore, enhanced lower hybrid waves are very plausible in the downstream region in the shocks' vicinity, whereas accelerated electron beams generate plasma waves along their path.

S13-P06

DISCRETE ELECTROSTATIC EIGENMODES ASSOCIATED WITH IONOSPHERIC DENSITY STRUCTURE

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Radio emissions emanating from the Earth and other planets are often characterized by discrete frequency structures. For example, recent ground-based observations of auroral roar, an auroral radio emission which occurs near the second and third harmonic of the electron cyclotron frequency, show that it consists of fine frequency structure similar to that of AKR and other planetary radio emissions. These auroral roar fine structures, sometimes as narrow as a few Hertz, often occur in multiplets separated by the order of 1 kHz which drift up and down in frequency. Theoretical and experimental efforts to explain the generation of auroral roar suggest that in the source region near the F-region peak, the quasi-electrostatic Z-mode (or upper-hybrid) waves are first excited, partly converted to free-space radio waves, and subsequently observed on the ground. Using WKB-type calculations of the wave mechanics of upper-hybrid modes in a cylindrical field-aligned density structure, we show that discrete frequency eigenmodes are a natural consequence of such density structures. Discrete eigenmodes can exist within density enhancements but not within depletions. Cylindrical field-aligned structures the order of 100 m to several km diameter result in eigenmodes spaced by a few hundred Hertz as observed for auroral roar. Since structure of this scale size often occurs in the Earth's auroral ionosphere at F-region altitudes, it seems possible that the observed auroral roar fine structure results from this mechanism.

S13-P07

OBSERVATIONS OF IONOSPHERIC MF/HF RADIO EMISSION FROM SPACE

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We present observations of MF/HF ionospheric radio emission observed in the terrestrial magnetosphere by the Wind spacecraft. During active times radio signatures are observed that show characteristics similar to ground observations of ionospheric 'auroral roar', although to propagate to the spacecraft they must have been generated above the ionospheric F-layer peak. We suggest that the emissions are generated on the topside ionosphere where the condition $f_{uh} \approx nf_{ce}$ is met. These observations represent a new component of the natural terrestrial radio spectrum as viewed from space.

S13-P08

INTERPLANETARY RAM PRESSURE INCREASES/DECREASES AND DAY-SIDE AURORAL VARIATIONS

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Solar wind ram pressure increases and decreases are shown to trigger dayside auroral intensifications and dimming, respectively. The auroral intensifications last for $\sim 10 - 15$ min and propagate towards the nightside along both the dawn and dusk flanks. In this study, we analyze interplanetary pressure pulse events and dayside auroral events during $1997 - 1999$ using WIND interplanetary magnetic field and solar wind plasma data and POLAR UVI data. The relationship between the intensity of interplanetary pressure pulses and the intensity and symmetry of dayside auroras will be shown statistically. The micro-mechanism(s) of the particle acceleration and the auroral propagation will be discussed.

S13-P09

SPECTRAL ANALYSIS OF FLICKERING AURORA OBSERVED AT SYOWA STATION

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To investigate the dynamical processes of flickering aurora in the auroral arcs, we developed multi-anode fast photometers (MFPs) with high space and time resolution in 1997. The MFP covers the entire field of view of 13.4 degrees with 52 channels, and the field of view of each channel is therefore about 1.27 degrees square. The highest data sampling furequency is 1000 Hz. Two MFPs were operated simultaneously in order to observe flickering aurora at two wavelengths : MFP-1 for N_2^+(1NG) band measurement and MFP-2 for N_2(1PG) band measurement. For selected fickering aurora events we calculated dynamic spectra of the intensities of individual MFP channels and obtained following results. Spectral peaks of "classical" flickering aurora with frequencies from 6 to 15 Hz are identified for all channels of the two MFPs. There is good correlation between the neighboring channels of each MFP. The spectra show additional peaks with higher frequencies. The duration of each peak is typically 1 sec. It is found that there are two cases for the wavelength dependence: one is identical peaks at the two wavelengths, while the other is different spectral peaks at the two wavelengths. These dynamic spectra often show some frequency dispersion and harmonics structures. We will discuss the role of ion cyclotron waves to produce fickering aurora.

S13-P10

THE CURRENT VOLTAGE RELATIONSHIP IN TIME-VARYING POTENTIAL STRUCTURES

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The upward field-aligned currents are believed to be closely related to generation of the parallel electric field over the discrete aurora. Using Akebono LEP and MGF data, we have studied the relationship between the upward field-aligned currents and the potential difference in the midst of the auroral particle acceleration region. We compared the current densities calculated from the Knight's static model with those estimated from the magnetic field perturbation and by integration of the electron distribution function as well. We have found that the model currents agree well with the currents estimated by integration of the electron distribution functions above the peak energy, which is consistent with the expectation from Knight's theory. However, the total currents estimated from the MGF data were more than several times greater than the model values. This fact suggests that low-energy electrons below the peak energy carry the upward field-aligned currents dominantly. An important feature is that most of these low-energy electrons are populated in a phase-space region, that is considered as "inhibited", or trapped in the time-stationary adiabatic theory. These electrons often show a cylindrical shape or conical distribution with large loss cone in the velocity space, and they are interpreted in terms of time-varying potential structures above and below the spacecraft. We suggest that these electrons can also contribute to the field-aligned currents, if the potential difference above and below the satellite also varies in time. Using test particle simulation, we have calculated the field-aligned currents in the various time-varying acceleration regions, and found that the low energy electrons can effectively contribute to the field-aligned currents when the oscillating electric fields exist at observation point. We compare the results

to the data observed by the Akebono satellites, and discuss about the time-variations of the potential differences in the auroral particle acceleration region.

S13-P11

ENERGY SEPARATION EVENT OBSERVED WITH ALL-SKY IMAGER AT SOUTH POLE STATION

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We have deployed an all-sky imager which observes monochromatic image of aurora at Amundsen-Scott South Pole Station since 1997. The imager have observed monochromatic images of 4 different wave length, *i.e.*, 557.7 nm, 630.0 nm, 427.8 nm, and 700.0 nm. In the austral winter season, the imager obtains an image in about 2 minutes and the total of the images adds up about 30,000 frames every year.

We have observed several chances of energy separation events, which show that the luminous region of 557.7 nm wave length image is spatially separated from that of 630.0 nm image. This separation indicates that the energy distribution of precipitating electrons are different depends on its location. And also indicates that the regin of intensified 630.0 nm luminosity has higher energy particle precipitation than that in 557.7 nm intensified region.

We will show the results of detailed analysis of these events and a possible mechanisms of this phenomena.

S13-P12

PLASMA WAVES IN THE RELATION TO HEATING HEAVY IONS IN THE POLAR CUSP REGION: ROCKET EXPERIMENT

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In the earth's polar cusp, we frequently observe that energetic heavy ions flow up from the ionosphere to the magnetosphere and that they are heated in the perpendicular direction relative to the ambient magnetic field. The most plausible heating mechanism is the wave-particle interaction. The former spacecraft and rocket experiments show that the intense broadband emissions in the frequency range of Lower Hybrid Resonance (LHR) frequency can be observed correlating with the detection of heated ion velocity distributions. However, the generation mechanism of this broadband emissions and detailed heating processes due to these waves are still unclear. In order to identify this mechanism, we will conduct the SS520-2 rocket experiment in the polar cusp region in November, 2000 and investigate the acceleration and the heating process of heavy ions. This rocket experiment is conducted by leadership of the Institute of Space and Astronautical Science (ISAS) in Japan. We are in charge of developing the onboard plasma wave measurement system called Plasma Wave Analyzer (PWA). The PWA system consists of 2 different types of receiver. They are waveform capture receivers and high frequency spectrum analyzer receiver. The waveform capture receivers have the capability to observe two components of electric field waveforms up to 15 kHz and one component of magnetic field waveforms up to 1 kHz simultaneously. The observed waveform data are compressed in real time by the onboard Digital Signal Processor (DSP) and telemetered to the ground. The high frequency spectrum analyzer covers the frequency range from 10 kHz to 3 MHz. This receiver makes use of the Digital Down Conversion (DDC) technology and this DDC technology allows us to develop a very lightweight receiver. These sophisticated receivers will provide us with important information for identifying heating processes of heavy ions.

S13-P13

MOLECULAR ION OUTFLOW IN THE TOPSIDE POLAR IONOSPHERE

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Satellites found molecular ion heating and outflow forming with conic distribution in the topside polar ionosphere. Suprathermal ion Mass Spectrometer (SMS) on Akebono satellite also obtained the phenomena of N_2^+, O_2^+, and NO^+ ion heating. However, the generation mechanisms are not understood in detail because we do not have enough data on molecular ion heating events. We calculated N_2^+ ion density distribution, which could be a source of N_2^+ ion heating and outflow, and discussed the possibility of optical observations of N_2^+ ion from ground. Our simple model can apply to simulate N_2^+ density distribution for polar night with high zenith angle. Simulations of N_2^+ density distribution indicate that N_2^+ up-flow is strongly associated with He^+ up-flow and charge exchange reactions between He^+ and N_2 are very important in the topside polar ionosphere. We suggest that a part of N_2^+ up-flow observed by satellites may be generated by reactions between local N_2 and He^+ coming from low altitude as polar winds or conics.

S13-P14

PARTICLE SIMULATIONS OF ELECTROSTATIC SOLITARY WAVES IN THE AURORAL REGION

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We study the formation mechanism of two-dimensional solitary waves observed in the auroral region via two-dimensional electrostatic particle simulations. The FAST satellite observed very strong electrostatic solitary wave (ESW) in the downward current regions of the mid-altitude auroral zone, and the Polar satellite also succeeded in detecting ESW in the polar region. These ESW are reported to have isolated two-dimensional structures. The present simulation study demonstrates that such isolated two-dimensional ESW can be generated by a simple electron two-stream instability. We performed two simulation runs, one is a run without ion dynamics and the other is a run with ion dynamics. By comparing these two runs, we found isolated two-dimensional potentials are generated due to the ion dynamics. Due to the ion dynamics, however, quasi-perpendicular lower hybrid waves are strongly excited through coupling with parallel drifting electron potentials. Potentials are divided in the perpendicular direction by these lower hybrid waves, forming isolated two-dimensional potentials. Through this coupling process, we confirmed that ions are thermalized in the direction perpendicular to the ambient magnetic field. We will discuss effects of this thermalization process on on the ion heating in the auroral region.

S13-P15

COORDINATED AKEBONO AND EISCAT OBSERVATIONS OF SUPRA-THERMAL ION OUTFLOWS IN THE NIGHTSIDE AURORAL OVAL REGION

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We have investigated ion outflows in the nightside auroral oval region on February 16, 1993 in which an ion outflow event was observed simultaneously in the topside ionosphere with the EISCAT radar and in the polar magnetosphere with the Akebono satellite. In this event the Akebono data showed that two distinct regions with different features appeared alternately. One is characterized by the presence of suprathermal ion outflow, downward field-aligned current, and intense broadband electrostatic ELF wave, while the other is characterized by the presence of auroral electron precipitation and upward field-aligned current. On the other hand, the EISCAT VHF radar data showed the presence of an ion outflow with enhanced ion temperature. The altitude of the ion outflow region gradually shifted downward from 1200 km to 500 km for about 25 min showing an inclined structure in the range-time diagram. An enhanced electron temperature and density region with a similar inclined structure appeared adjacent to this ion outflow region. These results suggest that the ion outflow region and the auroral electron precipitation region are adjacent, and extend along the magnetic field lines from the ionosphere to the magnetosphere. Based on these results, we have proposed a model for the ion outflow event as follows. In the nightside auroral oval region, a downward FAC region exists near the edge of the inverted-V type electron precipitation region due to the continuity of current. In the downward FAC region, ionospheric upward moving electrons carry downward current. This upward thermal electron beam can generate electrostatic ion cyclotron waves in the ELF frequency range. Electrostatic ion cyclotron waves cause transverse ion heating effectively at the top of the ionosphere through an ion cyclotron resonance. The heated ions move upward under the conservation of kinetic energy and adiabatic invariant and result in ion outflows.

S13-P16

HYDROGEN AURORA (Hα) REGION AND EASTWARD ELECTROJET CURRENT REGION DURING THE INITIAL PHASE OF THE MAGNETIC STORM ON FEBRUARY 18, 1999

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On February 18, 1999 during the initial phase of the magnetic storm an intense hydrogen aurora region was observed from 04:10 to 05:00 UT at Dome2 near by Dawson City, Yukon, in the evening sector. The intense hydrogen emission region almost disappeared just at the time starting of the subsequent substorm expansion which reached as much as 300 nT in the WDC-C *AL* index, Kyoto. Bright region with hydrogen emission limited in latitudinal width of about 800 km and bounded in the eastern end visible in the field of view was gradually shifted for the south and west direction with velocities of 0.5 km/sec and $1-3$ km/sec, respectively. A region with eastward electrojet current is found enhanced linked with intensification of hydrogen emission within similar logitudinal extent but the current center is located in the high latitude side of the hydrogen emission and is looked partly overlapped with narrow region of an auroral arc produced by electron precipitation. All those features are basically well understood by Hall current effect in the ionosphere controlled by combination of magnetospheric convection and enhancement of polarization field produced by energetic protons subjected to magnetic drift although the role of upward field-aligned current carried by electron precipitations in the high latitude border is unclear.

S13-P17

CONTROL MECHANISM OF SEASONAL VARIATION OF AURORAL KILOMETRIC RADIATION

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As the control mechanism of the seasonal variation of auroral kilometric radiation (AKR), it has been proposed that AKR's are directly blocked by increasing plasma density due to the upwelling plasma from the ionosphere. They are based on the theory that cyclotron maser instability (CMI) can not work in high plasma density condition, and the observation results that the seasonal dependence is clearer for AKR's from low altitude sources than those from high altitude sources. However, based on the observation by the Akebono satellite, we have found many data in which AKR can be generated even in high density plasma region where $f_p/f_c > 0.5$. These results suggests that there exists generation mechanism of AKR being different from CMI mechanism. As the generation mechanism under the condition of high f_p/f_c, we have investigated the Doppler mode conversion (DMC) process. By the numerical calculations of total gain of UHR waves and energy conversion rate from UHR waves to R-X mode waves, it has been shown that intense AKR can be generated via the DMC process even in high plasma density region where $f_p/f_c > 0.5$. Furthermore, based on the analyses of the occurrence frequency of upward-flowing ion (UFI) events observed by the Akebono satellite, the altitudinal distribution of the acceleration region of auroral particles show the same seasonal variations with that of AKR sources. The lower limit altitude of the occurrence of UFI event is shifted up to 5000 km in the summer polar region, while that is shifted down to 3000 km in the winter polar region. The similarity of seasonal variations between the lower limit altitude of AKR sources and that of UFI events suggests that AKR sources are not controlled by the emission conditions of CMI processes, by the formation conditions of acceleration regions.

S13-P18

LOW FREQUENCY CONTINUUM RADIATION OBSERVED BY GEOTAIL IN THE MAGNETOTAIL

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Low-frequency continuum radiation, which is called "lobe trapped continuum radiation" (LTCR), has been observed by the plasma wave instrument (PWI) onboard GEOTAIL at frequencies as low as 1 kHz in the magnetotail. The spectral structure of this radiation is similar to the higher-frequency (more than several tens of kHz) "normal" continuum radiation generated at the Earth's plasmapause around the equator. The LTCR is sometimes accompanied by strong electron cyclotron harmonic (ECH) waves near the plasma sheet boundary layer (PSBL). Such ECH waves, which would be converted to Z-mode waves then to O-mode waves in a steep electron density gradient perpendicular to the geomagnetic field line of the PSBL, are a possible source for the LTCR. Enhancement of the LTCR intensity is observed in the lobe region along with enhancement of the low-frequency component of auroral kilometric radiation (AKR). Since the low-frequency AKR is enhanced by energetic electrons injected from the tail region during a substorm, the enhanced LTCR could also be generated by such an electron injection associated with the same substorm. By comparing the PWI observations and ground-based geomagnetic data, we will examine the correlation between enhancement of LTCR and the geomagnetic activity, and discuss a possible mechanism of LTCR generation during a substorm.

S13-P19

PLASMA-MASER INSTABILITY OF EM RADIATION IN PRESENCE OF LH TURBULENCE

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The problem of conversion of wave energy with a large change of frequency is important to laboratory as well as space plasmas. One of the attractive possibilities is connected with plasma-maser instability, which occurs when nonresonant as well as resonant plasma oscillations are present.

In this paper we study the generation of electromagnetic radiation based on the plasma-maser interaction among the electrostatic lower hybrid turbulence and accelerated electrons. The plasma-maser doesn't require any matching conditions between the resonant and the nonresonant wave frequencies, and electromagnetic radiation with frequency well above the local electron gyrofrequency is possible. The possible application of the mechanism to AKR (AKR bursts are often observed at frequencies well above the local gyrofrequency together with electrostatic lower hybrid turbulence) and solar flare emissions are discussed.

S13-P20

BROADBAND HF WAVES EXCITED IN THE POLAR CUSP AT THE IONOSPHERIC ALTITUDES DURING STRONG GEOMAGNETIC STORM

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The cusp region is very sensitive region of the Earth environment for the changes of geomagnetic condition during magnetic storm. The high time resolution wave measurements together with electron and ions energetic spectra measurements registered on the board of Freja satellite was used to study the response of ionospheric plasma within cusp-cleft region to the strong geomagnetic storm. Both the electrostatic and electromagnetic emissions have been detected during the particle injection in the VLF frequency as well as high frequency whistler waves and plasma electron waves. Strong wave activity associated with these electrons are manifested by VLF and HF modes.The aim of this paper is to study the typical response of top-side ionospheric plasma within cusp-cleft and analyse the property of whistler mode excited during strong geomagnetic disturbances.

S13-P21

OPTICAL AND PARTICLE SIGNATURES OF MAGNETOSPHERIC BOUNDARY LAYERS NEAR MAGNETIC NOON: SATELLITE AND GROUND-BASED OBSERVATIONS

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We present a set of satellite and ground-based observations suggesting that energetic magnetospheric electrons cannot be used as an unambiguous discriminator between open and closed field lines on the dayside. Using two data sets from the DMSP F13 and NOAA-12 satellites flying through dayside Type 1 cusp aurora (both close in time and space), we reach two apparently incompatible conclusions. Cusp/mantle precipitation, stepped cusp signatures and antisunward convection in the DMSP F13 data set strongly suggest open magnetic field lines. On the other hand, NOAA-12 observed a mixture of magnetosheath and isotropic energetic particles. Trapped energetic electrons are traditionally regarded as being on closed flux. However, in addition to earlier proposed trapping on open field lines, we suggest that transmission lines connecting merging sites near the cusp in southern hemisphere with the northern auroral ionosphere can be several tens of R_E long. Alfvén wave transit times of several minutes may make it impossible to determine from satellite measurements in the ionosphere whether magnetic field lines threading LLBL plasmas are open or closed. New research tools will be needed to unify understanding of complementary particle measurements from the DMSP and NOAA satellites.

S13-P22

OBSERVATIONS SUPPORTING AN O-SHAPED POTENTIAL MODEL AND A SELF-CONSISTENT MECHANISM FOR ITS FORMATION

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We have suggested that the electric potential contours above stable auroral arcs (steady inverted-V regions) are actually O-shaped rather than U-shaped, *i.e.* that the upright legs of the U-potential mainly close somewhere around the 15000 – 25000 km altitude range instead of extending deep into the magnetosphere. The first observational evidence that lead us into the O-shaped model was the lack of convergent perpendicular electric field signatures above 20000 km. Other observational evidence includes the shapes of electron and ion distribution functions simultaneously measured at high and low altitude in magnetically conjugate points. We give a review of the observations.

If particles move adiabatically, a potential barrier filters out those precipitating electrons whose energy is less than the depth of the barrier. This produces inverted-V spectra, which is a benefit of the model, but it also makes it necessary to invoke wave-particle interactions on top of the potential model to explain the measured auroral energy fluxes. By feeding electron data measured above 20000 km in a test particle simulation we study how realistic inverted-V spectra are produced if various potential models and wave-particle interaction schemes affect the electrons. The result is that the O-shaped model can reproduce the observations quite well provided that it is combined with waves feeding about 50 – 200 eV electrons in the loss cone at about 13000 – 20000 km altitude range. We give a physical explanation for this result. We also point out what produces the negative charge cloud needed to maintain the potential barrier. This self-consistent model for the formation of inverted-V precipitation is in agreement with the large body of satellite data below about 13000 km while also being compatible with the more recent observations at higher altitude.

S13-P23

RELATIONS BETWEEN LOWER HYBRID CAVITIES AND MAGNETOSONIC WAVES OBSERVED BY THE FREJA SATELLITE

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A large amount of lower hybrid cavities (LHC) (also called lower hybrid solitary structures) have been observed by the Freja satellite. Electric field data inside the some areas containing LHCs also show an electromagnetic wave at frequency below the observed lower hybrid wave. This electromagnetic wave is clearly separated from the lower hybrid wave in frequency and has a lower amplitude. It can most probably be interpreted as the magnetosonic wave. The two frequencies are also seen on the scale of individual cavities where the upper frequency is interpreted as a propagating mode, and the lower frequency as a trapped mode.

S13-P24

ULF ACTIVITY IN THE AURORAL OVAL AS OBSERVED BY THE MICROSATELLITE ASTRID-2 AND THE GREENLAND MAGNETOMETER CHAIN

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Electromagnetic observations made onboard micro-satellite Astrid-2 over Greenland magnetometer array are analyzed during periods of intensification of the westward AEJ and Pc 5 activity in the morning sector. Modeling of the ionospheric EJ from the ground magnetometer data shows that ULF activity tends to be localized in the same latitudinal range as AEJ. In virtually every pass of Astrid-2 through a gradient of geomagnetic field, indicating an occurrence of FACs, burst of wide-band noise is observed in both electric and magnetic components. In the range from about 0.01 Hz to the Nyquist frequency (8 Hz) spectral power spectra have "colored-noise" forms, probably, corresponding to a fractal hierarchy of spatial scales from few hundreds km to few km. Spectral analysis of bursts with the maximum entropy method reveals the spectral power enhancements at frequency about $1-4$ Hz, which correspond to spatial scales about few km. The apparent wave impedance has growing frequency dependence, indicating a presence of DAW. The frequency-dependent enhancement of electromagnetic noise is explained as a result of resonant conversion of MHD disturbances into DAW. This process may be visualized as breaking of large-scale MHD wave approaching a magnetic "shore" into small-scale electromagnetic "splashes."

S13-P25

A NEW INTERPRETATION OF LOW-FREQUENCY TURBULENCE IN AURORAL REGIONS

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Low-frequency turbulence 0 – 500 Hz is omni-present in all active auroral regions and it is associated with electron and ion acceleration. We show that gross properties of this turbulence are determined by small-scale structures Doppler shifted to higher frequencies in the satellite frame. The spatial structures are found to be related to Dispersive Alfvén Waves (DAW) which form a turbulent cascade where the energy is transferred from large scale convective flows to increasingly smaller scales. The DAW turbulence is also shown to form nonlinear spatial singularities that correspond to auroral arcs at the electron skin-depth scale.

S13-P26

STUDY OF NONLINEAR DYNAMICS OF AURORA BY TV DATA

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TV data obtained during developing of an auroral form contains information about spatial and temporal dynamics of the form generation. It is possible to investigate the spatial distribution of auroral luminosity in each image. Also one can study the temporal dynamic of aurora using the virtual "photometers" or keograms. In this report we investigate the temporal dynamics using information about the spatial distribution of auroral luminosity to define the metric in "space of images." The algorithm of Grassberger-Procaccia has been applied to obtain the correlation dimension as a characteristic of the temporary chaos in sets of TV images of aurora. The approach has been tested by simulated sets. Results for TV observation of different auroral forms have been presented.

S13-P27

CHARGED PARTICLE FLUXES IN REGION WITH TURBULENT ELECTROSTATIC SOLITARY STRUCTURES IN AURORAL PLASMA

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A turbulent acceleration of charged particle fluxes near a substantial upward going magnetic field-aligned electric current is considered. Conditions in the auroral magnetosphere are known to be favourable for an excitation of plasma turbulence in the form of oscillating solitary electrostatic structures. The model of turbulent structures and its statistics is selected to be conformed with results of experimental observation and numerical calculations. The solution of stationary kinetic equation for particle fluxes in turbulent nonuniform layer is obtained. It is shown that electron fluxes accelerated by turbulent electrostatic structures move almost along the magnetic field while ion distributions are strongly anisotropic. Conditions of a formation of particle fluxes with distinguished energies are determined. Obtained theoretical results are in a qualitative agreement with the known experimental observations in the disturbed auroral magnetosphere concerning with particle fluxes up to energies of several keV.

S14-01

POLAR CAP BOUNDARY LAYER WAVES: LOCATION, INTERPLANETARY DEPENDENCE AND NATURE

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S14

Polar Cap Boundary Layer waves are ELF/ULF electric and magnetic waves detected on field lines just adjacent to the polar cap, thus their name. Waves are present at this location 96 % of the time. The wave latitude-local time distribution is shown to be the same as that of the auroral oval. The most intense waves are detected coincident with the strongest magnetic field gradients (field-aligned currents). Local noon and midnight wave intensities are the greatest when the interplanetary magnetic field $B_z < 0$. Specific frequency bands of whistler-mode waves are identified: $\sim$ 200 Hz, $1-2$ kHz and $\sim$ 5 kHz. Assuming resonant interactions, energies for electron and ion beams are derived. Two types of intense electric waves are present: solitary bipolar pulses (electron holes) and Langmuir waves. The PCBL waves are most likely a consequence of instabilities associated with auroral field-aligned currents. The currents have in turn been ascribed to be due to magnetospheric convection driven by the solar wind. One consequence of the presence of the waves at high altitudes is diffusion of magnetosheath plasma into the magnetosphere and magnetosphere plasma out into the magnetosheath.

S14-02

NONLINEAR ELECTROSTATIC TURBULENCE AT THE BOW SHOCK

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We present a study of nonlinear electrostatic turbulence observed at 33 separate, predominantly quasi-perpendicular, bow shock crossings by the Wind spacecraft. High time-resolution waveform samples show electrostatic, ion acoustic timescale nonlinear wave features and discrete bipolar structures that are interpreted as electron phase space holes. The power spectrum of the bipolar structures is shown to be consistent with earlier spectral density measurements at the bow shock. We solve the Rankine-Hugoniot problem for each shock to obtain shock parameters and find that both upstream β and magnetosonic Mach number M_{ms} are anti-correlated with the wave intensity. We also find a positive correlation between wave amplitude and the electron temperature change $\Delta T_e/T_e$, which is a proxy for the deHoffman-Teller potential $[\Phi_{HT}]$. The wave occurrence probability per unit length shows that the most intense waves are localized in the shock ramp, and probably then convect downstream. Probability of occurrence also shows that the most intense waves favor quasi-perpendicular shock geometry and large electron to ion temperature ratio T_e/T_p. We show that the waves are polarized along the local magnetic field direction and that the energy in the bipolar spikes is often a large fraction of the electron thermal energy $e\phi/k_bT_e \approx 0.1$. We discuss these results and suggest a generation mechanism.

S14-03

TURBULENCE ANALYSIS THROUGH BOUNDARY LAYERS

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The objective is to describe some of the techniques that can be used as diagnostics for simulated and experimental plasma data. Two different approaches will be considered.

In the familiar eulerian approach, various wave-related quantities such as the dispersion relation, the linear growth rate, and nonlinear wave couplings can be quantified using time-frequency methods. A robust inference of these quantities at boundary layers is particularly important, and the role played by nonlinear wave interactions will be illustrated by some examples.

The lagrangian approach gives a different viewpoint, in which the dynamics of tracer particles can be studied. Attention will be given to transport processes, and the possible existence of anomalous diffusion, using simulated data.

S14-04

FORESHOCK PROCESSES AND THEIR RELATIONSHIP TO MAGNETOPAUSE MOTION

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Processes at the bow shock energize and reflect a small fraction of the solar wind plasma incident upon that boundary. The beam of reflected particles is unstable to the ion cyclotron instability, which scatters and thermalizes the reflected particles to create a hot diffuse population that compresses neighboring solar wind parcels as it expands. The resulting transient ($1 - 20$ min) perturbations in solar wind parameters can be dramatic, particularly immediately outside the subsolar bow shock. Densities and field strengths on solar wind parcels connected to the bow shock can fall by a factor of 2 or more, whereas densities field strengths on neighboring unconnected parcels can increase by a factor of 2 or more. The most notable events occur during the interaction of IMF tangential discontinuities with the Earth's bow shock. Because there is a quenching threshhold for the flux levels of the reflected energetic particles, the most significant 1-D simulations and observations show that the pressure variations associated with the foreshock disturbances can propagate across the magnetosheath essentially unchanged. Case and statistical studies suggest that pressure variations generated in the foreshock probably drive the majority of magnetopause motion and suggest that they may be an important cause of dayside auroral brightenings and ionospheric traveling convection vortices. However, by comparison to magnetic reconnection they contribute little to the overall solar wind-magnetosphere interaction.

S14-05

REVIEW OF RECENT RESULTS ON WAVES IN THE ELECTRON FORESHOCK

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Bursty Langmuir-like waves with widely varying fields are routinely observed in Earth's foreshock, the region of the solar wind magnetically connected to the bow shock. These waves are believed to be generated by electron beams, formed by time-of-flight effects from electrons reflected and accelerated at the bow shock. These waves and electron beams persist tens of Earth radii from the bow shock, usually producing observable levels of radiation near the electron plasma frequency and its harmonic. This paper reviews the observations, theory, and simulation of the Langmuir-like waves. Particular foci are stochastic growth descriptions of the wave statistics, the occurrence or not of nonlinear wave processes, linear mode conversion, evidence for transverse polarization of the Langmuir-like waves, and the occurrence of some localized wave packets.

S14-06

PROPERTIES OF MASS-LOADING BOUNDARIES AT COMETS AND MARS

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Despite their very different nature, active comets and planet Mars reveal many similarities in their interaction with the solar wind and in the characteristics of the subsequent plasma boundaries. The absence of any measurable large-scale planetary magnetic field at Mars makes the interaction to be mainly of the atmospheric type. But this interaction starts far upstream from the bow shock as a consequence of extended neutral corona. Ionization and subsequent pickup of the exosphere matter may provide a mass-loading effect similar to the one at comets. The microscopic processes at work include wave particle interaction as revealed, *e.g.*, from waves at the proton cyclotron frequency upstream from the bow shock, nonlinear steepening and associated higher frequency dispersive whistlers. For both comets and Mars, the magnetosheath displays a high level of wave activity and ends at the magnetic pileup boundary (MPB). This thin and sharp permanent boundary marks the entry in a region of less-disturbed, higher magnitude magnetic field draped around the dense ionosphere. The properties and the role of compressive low frequency waves on both sides of the MPB for both comets and Mars are discussed.

S14-07

KINETIC SIMULATION OF THIN CURRENT SHEET BOUNDARIES

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Thin current sheets (TCS) form inside and at the boundaries of magnetized space plasmas as a consequence of the application of external forces. Due to their importance for structure and dynamics of space plasmas it is necessary to understand the limits of stability and decay dynamics of TCS properly. Since the thickness of TCS compares with the characteristic particle scales, investigations have to be carried out kinetically. We report recent and current results obtained by theoretical investigations and by simulating TCS structure and dynamics kinetically by means of particle code simulations. In particular we consider the influence of the external plasma and field conditions. The new findings apply to solar, solar wind and magnetospheric plasmas.

S14-08

IDENTIFYING NONLINEAR PROCESSES BY HIGHER-ORDER STATISTICAL TESTS

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Tests of hypotheses based on Higher Order Statistics are reviewed in the particular context of the identification of non-linear processes in space plasma. The time series under study are associated with the measurements of electric or/and magnetic field components, or/and counting rates of particles. Gaussianity and linearity tests are applied to discriminate between the upstream and the downstream regions of the Earth's bow shock using magnetic field measurements (AMPTE). Detection of transient signals are used to select time intervals where non-linear wave-particle interactions are taking place (ARCAD-3).

S14-09

TWO-DIMENSIONAL HYBRID SIMULATIONS OF THE MARTIAN DAYSIDE

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S. Brecht [*GRL* **17**(9) 1990] published the first global hybrid simulation of a bow shock standing upstream of an unmagnetized conducting planet without atmosphere. *K. M. Moore et al.* [*JGR* **96**(A5) 1991] published the first global hybrid simulation of the Venusian shock owing to a proper scaling down of characteristic lengths. It iw worth noticing that *D. W. Swift* [*GRL* **22**(3) 1995] presented the first global hybrid simulation of the Terrestrial bow shock made with a very innovative code.

The small size of planet Mars allows global simulations of the Martian bow shock by hybrid codes. The absence of a large scale planetary magnetic field and the existence, due to the weak Martian gravity, of extended coronae of atomic oxygen and hydrogen explains that charge exchange processes, electron impact collisions and photoionization determine the interaction of planet Mars with the solar wind by substituting solar wind ions by ions of planetary origin or creating new ions.

A two-dimensional hybrid model of this interaction is presented which combines a collisionless solar wind made of protons and α particles with neutral coronae of atomic oxygen and hydrogen with densities given by exospheric models. Present simulations are restricted to the dayside, from the exobase up to 6 Martian radii.

This allows to study the dynamics of solar wind primaries as well as pickup ions and their interaction with upstream or downstream waves and the bow shock itself taking into account its curvature and the varying shock normal angle along its profile. The quasi-perpendicular shock is stationnary on timescales of 100 gyro-periods of protons but the quasi-parallel shock exhibits a high variability on timescales of 10 gyroperiods of protons. One of the most salient features of the model are a pronounced non-gyrotropy of the pickup ions upstream of the bow shock and a non-hydrodynamic character of the plasma flow around the planet.

S14-10

COMPUTER SIMULATION OF WAVE AND ELECTRON DYNAMICS RELATED TO THE BOW SHOCK

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The wave natures observed in the vicinity of the Earth's bow shock change drastically at the crossing of the shock boundary. High time resolution plasma wave data obtained by Geotail spacecraft revealed that the transition and downstream regions of the bow shock exhibit highly variable wave activities with different wave natures from those in the foreshock region. The waves are often highly nonlinear, transient and short-lived as represented by solitary spikes or electromagnetic whistler packets. These characteristics are without doubt related to fast time-scale dynamics of electrons in those regions. To supplement the spacecraft data and to fill the gap in the time resolution of wave and particle data, we have performed one-/two-dimensional full-particle computer simulations using our KEMPO particle code. Our computer simulations could reproduce the production of the shock potential and related electron beams in the transition region between the foreshock and the downstream region. We confirmed that several electrostatic or electromagnetic waves can be excited in the upstream and transition regions in these computer simulations. As one example of the electrostatic waves, we revealed that the ion acoustic waves can be excited due to the current-driven instability at the transition region in the case of the quasi-parallel shock. The obtained waveforms and their natures agree very well with Geotail spacecraft observations in the Bow shock. We will discuss the results of these computer simulations in terms of physics and of observed phenomena.

S14-11

GENERATION OF PLASMA OSCILLATIONS AND HARMONICS: SIMULATIONS AND OBSERVATIONS

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The electron foreshock region upstream of the Earth's bow shock is a naturally occuring plasma physics laboratory rich in linear and non-linear wave-particle processes. Observations show the presence of plasma frequency oscillations, waves at twice the electron plasma frequency, and waves with frequencies orders of magnitude below the electron plasma frequency. Electron streaming distributions and density gradients are also common in the electron foreshock. Using numerical simulations and analytic theory, in close conjunction with observations, we will examine generation mechanisms for these different waves including decay processes, wave-wave interactions, and linear mode conversion. Emphasis will be placed on what role these wave-particle interactions play for the region as a whole in terms of dissipation and transport.

S14-12

EVIDENCE OF COSMIC RAY MODIFIED-INTERPLANETARY SHOCKS

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The spatial/temporal structures of so-called cosmic-ray-modified shocks (CRMSs) are investigated observationally. While CRMSs are believed to be essential in many astrophysical shock phenomena, observational evidence had been limited to the weak CRMS-feature at the earth's bow shock, where a clear-cut differentiation between spatial and temporal structures is usually difficult. Our recent observational results have changed such a research situation: We have shown

1. that a propagating interplanetary shock on 21 Feb 1994 had the CRMS feature, and
2. that a clear observation of the spatial CRMS structure at the earth's bow shock was obtained.

We will discuss physical significance of these new observations.

S14-13

SLOW MODE SHOCKS IN THE EARTH'S MAGNETOTAIL

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GEOTAIL plasma and magnetic field experiments during the distant-tail orbit period revealed that about 10 percent of the mid-tail to distant-tail plasmasheet-lobe boundaries can be identified as slow-mode shocks. Using the same method we used for identifying slow-shock boundaries in the distant-tail region, we tried to identify slow-mode shocks in the near Earth magnetotail. It has turned out that slow-shock boundaries with nearly the same structure as those observed in the distant magnetotail were observed in the region farther than about $20R_E$ while no plasmasheet - lobe boundaries were identified as slow mode shocks in the near-tail region within $20R_E$. Our statistical study shows that the conservation of the tangential momentum between the upstream (lobe) and the downstream(plasmasheet) regions is not fully satisfied within about $30R_E$ especially within $20R_E$. It has also turned out that most of the slow-shock boundaries observed between $20R_E$ and $30R_E$ were accompanied by substorm onset, which was identified, from the Pi 2 onset signature. The large geometrical factor of the GEOTAIL plasma instrument (LEP) enables us to investigate the detailed ion three-dimensional distribution function. In the upstream region, there is a foreshock region that is characterized by counterstreaming ions: backstreaming ions that flow from the shock surface toward the upstream region along the magnetic field and the lobe cold ions that flow from the upstream region into the shock surface. Similarly to the slow-shock boundaries observed in the distant magnetotail, the slow-shock boundaries in the near Earth magnetotail also have foreshock region. In addition to the two component ions observed in the distant magnetotail, we have found another ion component (hot ions flowing into the plasma sheet) coexist in the foreshock region of the near-tail slow-shock boundaries. These three component ions make the structure of the near-tail slow-shock boundaries more complex than that of the distant-tail slow-shock boundaries.

S14-14

KINETIC EFFECTS DURING MAGNETOPAUSE RECONNECTION

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Early attempts to document magnetic reconnection at the Earth's magnetopause were mainly based on stress balance and energy balance by using plasma moments. Details of the distribution function give additional information, like reflection and transmission of ions at the rotational discontinuity, and time of flight effects associated with the magnetopause layers. Recent observations of ions and electrons by Polar have identified the various scales in collisionless reconnection at the magnetopause, like the ion and electron inertial lenght scales. We will review these observations and will report on new kinetic simulations of magnetopause reconnection.

S14-15

INHERENT RELATIONSHIP BETWEEN RECONNECTION AND ENHANCEMENT OF WAVE ACTIVITY: GEOTAIL OBSERVATIONS

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Magnetic field reconnection has been proposed as a basic energy-conversion process, which occurs at many places in universe. Many observations have shown the evidence of reconnection mainly from the plasma and magnetic fields observations. However, the process of reconnection is extremely complicated and multifaceted. It is believed that reconnection can give rise to particle acceleration and temperature anisotropy, which in turn drives a variety of instabilities. Combining the wave and particle data with magnetic field and plasma observations, we have studied the process of magnetic reconnection on dayside magnetopause. It is revealed that there exist a strong inherent correlation between the extensive enhancement of wave activities and the magnetic reconnection process. It provides additional observations supporting the concept of reconnection from wave and wave-particle interactions. With the help of Plasma Wave Instruments (PWI), we study the properties of waves associated with magnetic reconnection. One of the interesting features is the first finding of broadband electrostatic noise (BEN) and Narrow electrostatic noise (NEN) in the region of low latitude boundary layer (LLBL), and it was closely related to reconnection. The characteristics of waves and wave-particle interactions associated with reconnection will be given on the basis of data survey of GEOTAIL skimming along the dayside magnetopause. Our results clearly demonstrate that wave activity and wave-particle interaction could give as an effective additional diagnostic tool or evidence for magnetic reconnection, more importantly, it provides significant clue to the details of the physical process of magnetic reconnection itself.

S14-16

THE STRUCTURE OF DAYSIDE MAGNETIC RECONNECTION LAYER

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GEOTAIL satellite has frequently observed rotational discontinuities accompanied with fast plasma flows at the dayside magnetopause boundary layer, where magnetospheric and magnetosheath plasmas are mixed. These rotational discontinuities are considered to be an evidence of dayside magnetic reconnection. We have performed a number of two-dimensional hybrid simulations (ion particle, charge neutralizing massless electron fluid) of the dayside reconnection layer where the plasma density, temperature, and magnitude and direction of magnetic field are different between magnetospheric and magnetosheath regions. The ion kinetic and Hall term current effects around the magnetic reconnection region play an important role to determine the characters of derived boundary layers. We will discuss the features of boundary layers in the cases of various magnetospheric and magnetosheath parameters, which might serve as a guide to the observations of dayside magnetic reconnection.

S14-17

SHOCK SEGMENTS OF INTERMEDIATE TYPE IN 3D MHD BOW SHOCK FLOWS WITH MULTIPLE INTERACTING SHOCK FRONTS

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Simulation results of 3D stationary MHD bow shock flows around perfectly conducting spheres and paraboloids are presented. For well-defined conditions of strong upstream magnetic field a new complex bow shock flow topology arises consisting of two consecutive interacting shock fronts. It is shown that for such magnetically dominated upstream flow conditions the leading shock front contains a segment of intermediate $1-3$ shock type. This is the first confirmation in 3D that intermediate MHD shocks, which were believed to be unphysical for a long time, can be formed for small-dissipation MHD in a realistic flow configuration. It is shown that perturbations of the upstream state in the above described MHD bow shock flows destroy the intermediate shock segments as expected, but that subsequently the intermediate shock segments are reformed at different locations on the shock front. This is a strong indication that intermediate shocks can be present at all times in a driven MHD plasma flow also when there are perturbations. It remains to be investigated if this flow topology with intermediate shock segments also arises for the bow shock flows of magnetized planets, which requires the detailed modeling of their magnetospheres in the simulations, and performing kinetic simulations.

S14-18

DOUBLE DISCONTINUITIES IN SPACE PLASMAS

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Double discontinuities were recently identified in interplanetary space and in the magnetotail when high-resolution plasma and magnetic field data were used to examine the detailed structure in the interior of slow shocks. A double discontinuity is a compound structure composed of a slow shock layer and an adjoining rotational discontinuity layer on the postshock side. This compound structure looks like a new kind of MHD discontinuity. Across the slow shock layer, the plasma density increases and the magnetic field intensity decreases. Through the rotational layer the magnetic field rotates by a large angle about the normal direction of the discontinuity surface while the plasma density and the magnetic field intensity remain nearly unchanged. In space plasmas the observation of double discontinuities is no less frequent than the observation of stand-alone slow shocks. In the magnetotail, our study supports that slow shocks and double discontinuities are semi-permanent structure at the boundary surface between the tail lobe and the plasma sheet region. Plasma and magnetic field lines continuously move across the boundary surface from the tail lobe to the plasma sheet and there is a conversion of magnetic field energy into plasma energy.

S14-19

WAVES AND PARTICLES AT COLLISIONLESS SHOCKS AND BOUNDARY LAYERS

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S14-P01

KINETIC THEORY OF ELECTROSTATIC TURBULENCE IN COLLISIONLESS SHOCKS AND BOUNDARY LAYERS

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Boundary regions that separate plasmas in a given state from another are replete with electric currents, energized and accelerated particles, and turbulence. Earth's bow shock and plasma sheet boundary layer are prime examples. Observations show that electrostatic waves and field-aligned electron beam are generated at the Earth's electron foreshock boundary and at the magnetotail. Primarily, these can be understood in terms of beam-generated Langmuir waves whose frequency lies close to the local electron plasma frequency (f_{pe}). In addition to Langmuir waves, however, electromagentic waves with twice the frequency of Langmuir waves ($2\ f_{pe}$) are also observed. Such a harmonic wave generation can only be explained in terms of nonlinear wave-wave and wave-particle interaction processes. Furthermore, there has also been reports that some of the observed harmonic waves are electrostatic, especially right at the edge of the foreshock boundary. Such a wave does not even exist according to standard plasma physics. Although some doubts have been raised that the electrostatic harmonic waves may be instrumental artifacts, which obviously points to the need for more careful observations and data analyses in order to fully understand their nature and properties, numerical simulation experiments amply provide convincing evidences that such a wave might actually exist in a turbulent plasma. In this presentation, a self-consistent theory of electrostatic turbulence, including the said electrostatic harmonic waves, will be presented. The theory generalizes the conventional weak plasma turbulence theory found in the literature.

S14-P02

MAGNETOSHEATH STRUCTURE ASSOCIATED WITH THE INTERACTION OF THE IMF ROTATION WITH A BOW SHOCK: NUMERICAL STUDY

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Complexity of the magnetosheath structure often makes it difficult to understand the physical processes occurred there. In the present study, we focus on the situation that the IMF rotational disturbance (an MHD rotational discontinuity) hits the terrestrial bow shock, consequences of which are investigated by numerical simulations using both MHD and hybrid codes. Results from both codes shows that the peculiar diamagnetic structure (enhancement of the density and the reduction of the magnetic field amplitude) emerges in the shock downstream, and linearly evolves with time after such an interaction between the discontinuity and the shock. In the context of MHD description, the boundary edges of this structure correspond to the different MHD (slow) shock waves, generated by this interaction, which are disintegrated due to the difference of each phase velocity. On the other hand, in the hybrid regime where particle dynamics determines the physical processes, we further clarify the microscopic mechanism of the accumulation of particles within this structure. The downstream of the shock ordinary shows large temperature anisotropy ($T_{perp}/T_{para} > 1$); where the particle energy parallel to the magnetic field is enhanced when the field rotational component is imposed on there. Such "forced" isotropization makes a pressure gradient which generates the diamagnetic current. As a result, the reduction of the magnetic field and the particle accumulation due to the induced mirror force takes place. The generated structure (variation in density and magnetic field out of phase) agrees well with the slow mode structure commonly observed in the magnetosheath. We will compare the results with GEOTAIL observation, where particle information from hybrid results can help to identify the consequence of the shock - discontinuity interaction more directly from the observational data.

S14-P03

MHD WAVE ACTIVITY AND PARTICLE TRANSPORT AT THE MAGNETOPAUSE

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Observations of compressional MHD waves in the magnetosheath with frequency in the range 0.01 to 0.1 Hz are well correlated with observations of transverse MHD waves at the magnetopause in the same frequency range. Comparison of spectrograms of wave amplitude and polarization strongly suggests that the waves result from mode conversion of compressional waves into transverse/kinetic Alfvén waves in the presence of strong gradients in the Alfvén resonance frequency at the magnetopause. We present (a) an observational survey of magnetopause crossings as a function of magnetic shear at the magnetopause and (b) a theoretical calculation of MHD wave structure in a sheared magnetopause geometry including particle kinetic effects. We compare wave amplitude, polarization, and spectral slope as a function of magnetic shear for the theoretical predictions and observational survey. The comparison reveals a striking similarity if the compressional waves in the magnetopause are generated nearly transverse to the magnetic field as is the case for the fastest growing modes. The agreement between the theory and observation suggests that much of the low frequency transverse wave activity observed at the magnetopause results from mode conversion of compressional waves into kinetic Alfvén waves which impact on the particle transport at the magnetopause.

S14-P04

SELF-CONSISTENT ELECTRON DISTRIBUTIONS IN THE 2-D FORESHOCK REGION

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Features of electron foreshock are analyzed with the help of a 2-dimensional electromagnetic full particle code where ions and electrons are treated as individual particles. Shock front curvature is fully simulated by a self-consistent way so that formation of the foreshock is reproduced without any simplifying assumption; time-of-flight effects are also fully involved. In the present case, curvature effects cover the quasiperpendicular range, and the shock is in a supercritical regime. The foreshock region is associated with electrostatic and electromagnetic enhanced fluctuations also evidenced in the simulations. In agreement with experimental data, local "bump-in-tail" patterns are well recovered in parallel distribution $Fe(v_{//})$ and correspond to electrons backstreaming upstream along the magnetic field lines. Present simulations allow to precise that local Fe have two components: a high energy component (with field-aligned beam signature) and a low energy component (with loss-cone signature). In addition, two types of "bump-in-tail" distributions, respectively broad and narrow, are respectively identified at short and large distance from the curved shock; these are due to different respective contributions of these two components. This distinction allows to identify more precisely the nature of the bump-in-tail pattern commonly evidenced experimentally (narrow type), which tends to be smoothed out when moving further within the foreshock .

S14-P05

QUICK ION INJECTION AND ACCELERATION IN QUASI-PARALLEL SHOCKS

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Although particle acceleration processes at quasi-parallel shocks have been widely discussed, the very initial injection from thermal to non-thermal (NT) energies is still controversial. Here we show that the non-linear wave-particle interaction at quasi-parallel shocks results in quick injection and quick further acceleration of NT ions (< several gyro-periods). Instead of an ensemble small amplitude random waves, a large-amplitude monochromatic upstream wave is set to propagate into the shock transition layer, and test particle orbits are deterministically calculated. The conversion of the wave at the shock front brings about quick injection of selected thermal ions into NT energies. Some of the NT ions leaving the shock front are quickly scattered back to the shock by the wave and experience repeated acceleration in relatively short interval. The resultant energy spectrum has the exponential shape upto about 100 times the upstream bulk flow energy. Results from self-consistent hybrid simulations and satellite observations support the above process.

S14-P06

LONG TIME EVOLUTION OF ELECTROMAGNETIC WAVES DRIVEN BY THE RELATIVISTIC RING DISTRIBUTION

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The ring distribution, with perpendicular free energy, is frequently observed in space, *e.g.*, downstream of planetaly shocks and in the neighborhood of comets. It is also expected to be formed in various regions of high energy astrophysical plasmas.

The ring distribution generates the electromagnetic waves via the cyclotron resonance. In a relativistic plasma, owing to the relativistic mass variation of particles, a wave mode around $k = 0$ is amplified in addition to the usual cyclotron waves with finite wavenumber k. We study excitation and subsequent time evolution of this mode by performing particle simulations using a plasma consisting of relativistic ring electrons and background positrons and electrons. In this study we focus our interests on the waves excited at $k = 0$ by neglecting explicit dependence to any spatial dimensions; this enables us to look at nonlinear evolution and saturation of the system with extremely high accuracy. We report that as the ring momentum is gradually increased the wave saturation level increases also, but as the ring momentum is further increased to exceed a certain critical value, the saturation level suddenly drops. This behaviour can be discussed in terms of a phase transition of nonlinear dynamical systems.

S14-P07

ACCELERATION OF CHARGED PARTICLES BY LARGE AMPLITUDE MHD WAVES: NON-MARKOV MODEL

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We discuss energy diffusion of charged particles by spatially correlated large amplitude magnetohydrodynamic (MHD) waves. The wave fields are given as superposition of four families (left/right hand polarization, parallel/anti-parallel propagation) of circularly porlarized Alfvén waves. When the wave phases are totally correlated, the wave field profile appears to be spatially localized wave packets. In the presence of such waves particles are accelerated twice the wave phase speed at each reflection, *i.e.* they are Fermi accelerated. A particle which was just reflected by a wave packet has an enhanced probability to encounter another oppositely propagating wave packet. Hence the particle motion depends on its past history, *i.e.* the process is non-Markovian. This non-Markovian character is eminent when two wave packets collide each other, since some particles can be accelerated efficiently as they are reflected back and forth many times by the wave packets in a short time. In this way, high energy tail of the velocity distribution function can be generated efficiently. We propose a simple statistical model to discuss non-Markovian acceleration of charged particles in a presence of phase correlated MHD waves.

S14-P08

CROSS FIELD TRANSPORT OF COSMIC RAYS: TEST PARTICLE SIMULATION STUDIES

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Fermi acceleration is important in shock acceleration of cosmic rays. For quasi-perpendicular geometry, in order that the process is operative, it is essential that particles can travel across the magnetic field lines so that they can repeatedly be accelerated at the shock. Here we study cross-field transport of charged particles in a two dimensional space by performing test particle simulations. The time stationary, power-law magnetic field turbulence is given perpendicular to the simulation plane. Qualitatively distinct diffusion processes are observed depending on the ratio of particle Larmor radius to the field fluctuation correlation length. We compare the calculated diffusion coefficients to that obtained by the quasi-linear theory, and further relate statistics of the field turbulence to that of the particle transport, by examining higher order structure functions.

S14-P09

ON NONSTATIONARITY OF SUPER-CRITICAL PERPENDICULAR SHOCKS

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We model the macro-structure of perpendicular shocks in the super-critical regime in the framework of a fluid model. We treat the incoming, the reflected, and the transmitted ions as independent elements of a multi-fluid, whereas the electrons as charge neutralizing background. Previous study by *Leroy* (1983) showed that the multi-fluid description can explain a number of features exhibited by hybrid simulations, including the morphology of the reflected gyrating ion stream and the dependence of the shock structure to the Mach number. On the other hand, since time stationarity was assumed in his model, it was not able to describe nonstationary features which may be intrinsic to shock waves in a certain parameter regime. We discuss structure and stability of perpendicular shocks, with particular emphasis on self-reformation of the shock front, which has been observed in full particle simulations and also in recent hybrid simulations.

S15-01

THE PHYSICS OF COLLISIONLESS MAGNETIC RECONNECTION

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Magnetic reconnection plays a critical role in the dynamics of the magnetosphere by providing a mechanism for the fast release of stored magnetic energy and by providing a point of entry for solar wind plasma. The rate of magnetic reconnection is controlled by the geometry of the dissipation region, where the ideal MHD description breaks down and the frozen-in condition is violated. Simulations have revealed that the nonlinear reconnection rate, as measured by the inflow rate into the magnetic x-line, is generally a constant ($\sim 0.1C_A$), independent of the mechanism which breaks the frozen-in condition and independent of the macroscopic system scale length L. The underlying physics for this result has been carefully explored. The dissipation region develops a distinct multi-scale structure in which the plasma dynamics at small scale lengths is controlled by whistler or kinetic Alfvén waves. The quadratic dispersion character of the waves is the essential ingredient leading to fast reconnection. At the magnetopause, diamagnetic effects associated with the pressure drop across the magnetopause can inhibit reconnection. The range of parameters for which this effect is important is being explored.

S15-02

MICRO AND MACRO SCALE PHENOMENA DURING MAGNETOTAIL RECONNECTION: RESULTS FROM HYBRID SIMULATIONS

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Hybrid simulations of magnetotail reconnection have shown that ion kinetic effects result in a variety of scales, from ion inertial lengths up to several tens of Earth radii. Near the reconnection region, which is not resolved by hybrid simulations with massless electrons, an ion pickup region of several tens of ion inertial lengths exists, where the electrons are magnetetized but the ions are still demagnetized. This region is also characterized by a standing large-amplitude whistler wave. Further away from the reconnection site a reconnection layer develops without slow mode shocks. At distances of 50 Earth radii this current sheet becomes unstable and a hot postplasmoid plasma sheet develops. The beams escaping the reconnection layer excite obliquely propagating electromagnetic ion/ion cyclotron waves, which heat the lobe plasma perpendicular to the magnetic field. The temperature anisotropy in turn excites parallel propagating Alfvén ion cyclotron waves, and eventually slow mode shocks emerge.

S15-03

UNSTABLE ION ACOUSTIC WAVES AS A SOURCE OF ANOMALOUS RESISTIVITY IN A COLLISIONLESS PLASMA

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We present results from a one-dimensional electrostatic Vlasov simulation which was used to study unstable current-driven ion-acoustic waves in a two-species plasma (electrons and H^+ ions). These waves can be shown to change the bulk momentum of each plasma species in the quasilinear and non-linear regime, and thus can contribute to anomalous resistivity in a collisionless plasma. We calculate the anomalous resistivity for different current densities using a Vlasov simulation and compare the results with those obtained from a method similar to that documented in *Lui et al.* (*JGR*, **98**, 153–163, 1993) where the bulk moments of the distribution function are evolved in time using a quasilinear equation. By comparing the two methods, we identify the change in resistivity due to plateau formation in the electron distribution function which is omitted in the bulk moment method. We compare the values of anomalous resistivity obtained for unstable ion acoustic waves with similar results for different wave modes, *e.g.* electro-magnetic cross-field current driven waves.

S15-04

KINETIC THEOTY OF MIRROR MODE TURBULENCE AS A BASIC PHASE TRANSITION IN HIGH-BETA PLASMA

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Mirror modes turbulence is a nearly persistent factor in the magnetosheath and is known to be driven by pressure anisotropy. In the presence of density and field gradients kinetic theory leads to drift mirror instability. We investigate this kinetic behaviour. It turns out that there is a close analogy between the drift mirror mode and a superconducting state. The drift mirror mode behaves similar to the Meissner effect in ordinary crystal superconductors. The distribution function of the particles splits into two components under the action of the mirror mode, one of them trapped the other passing. Of the trapped component a small percentage contributes to the compressive reduction of the magnetic field inside the mirror. This is itnerpreted as a phase transition effect in the high β plasma. Under well developed mirror turbulence the high β plasma evolves into bubbles of weak magnetic fields separated by normal magnetic field regions. We refer top antiparallel fields as well. In this case mirror modes drive nonstationary collisionless reconnection. Bubbles of low magnetic field are ejected from the reconnection site and appear as high β bubbles for instance in the lower tail lobe regions during active reconnection events.

S15-05

A STATISTICAL THEORY ON PRESSURE ANISOTROPY RELAXATION

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The relaxation of ion anisotropy by ion cyclotron waves has been studied based on a theory of statistical physics. Recent studies in numerical simulation, satellite observations, and laboratory experiments reveal that the upper bound of the proton anisotropy shows inverse correlation to the plasma β (ratio of the plasma gas pressure to the magnetic pressure) when the scattering is due to ion cyclotron waves. Theoretically this inverse correlation has been explained by the linear threshold in the past literature. The approach here is complementary to the linear analysis, and gives insight to the fully non-linear stage of the anisotropy relaxation process.

What we apply is a method of statistical mechanics: "Maximum Entropy Principle" proposed by *Jaynes* [1957]. The final state of the relaxation process will be the distribution that maximizes the entropy under given constraints. We would obtain an isotropic Maxwellian distribution if the constraints are the conservation laws of total energy and mass only. However, the particle scattering process by ion cyclotron waves has an additional constraint: the energy of a particle remains constant in the wave rest frame. With this additional constraint, we can derive the anisotropy/beta inverse correlation, which quantitatively agrees with observational, experimental and numerical results.
manuscript: http://www.mira.bio.fpu.ac.jp/~tadas/

S15-06

PLASMA TURBULENCE IN THE NEAR-EARTH PLASMA SHEET: ITS CAUSES AND CONSEQUENCES

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Global-scale, hybrid code simulations in the midnight meridian plane of the Earth's magnetosphere show fast earthward flows are generated by relaxation of the extended tail field. Large amplitude plasma turbulence is generated near the equatorial plane by collision of these flows with the ambient plasma. The turbulence is attributed to ion-ion, two-streaming instability. This turbulence forms just behind the expanding dipolarization front. Turbulent energy is radiated away from the equatorial plane primarily as as shear Alfvén waves. These waves propagate along magnetic field lines to the surface of the Earth at auroral latitudes. These waves carry filamentary currents, which are taken as proxies of discrete auroral arcs. The poleward motion of the footprint of the filamentary currents is due to the outward propagation of the dipolarization front and the turbulence following behind it. It appears that kinetic instabilities play an important role in the generation of the auroral arcs observed in the substorm expansion.

S15-07

ROLE OF KINETIC THEORY AND SIMULATIONS IN MICRO AND MESO SCALE PLASMA TRANSPORT PHENOMENA

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Inclusion of kinetic theory and simulation in meso-scale plasma transport studies have shown that kinetic processes produce plasma energization and cross-field transport, which in turn modify the large-scale plasma outflow. Using a one-dimensional generalized fluid model, that self-consistently incorporates the effects of kinetic instabilities, we have shown that the polar wind hydrogen ion temperature anisotropy can be reversed when the effects of kinetic instabilities are included in the fluid model. We have also studied the effects of small-scale structures in the transverse directions using kinetic simulations and incorporating its effects into 3D simulations. The results show that small-amplitude, short-scale filamentation of the parallel flow leads to local transport enhancement as well as significant transport enhancement on the global scale.

S15-08

DYNAMIC FLUID-KINETIC (DYFK) MODELING OF THE AURORAL IONOSPHERIC PLASMA TRANSPORT FROM 120 KM TO 4 R_E ALTITUDE

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Simulation of field-aligned auroral ionospheric plasma transport has been conducted with a variety of schemes, involving fluid, generalized transport, hybrid/semi-kinetic, and PIC/fully kinetic techniques. Each of these techniques has relative advantages and disadvantages for treating auroral ionospheric transport. Over the past decade, hybrid or generalized semi-kinetic (GSK) treatments were introduced to examine mesoscale field-aligned ionospheric plasma transport phenomena in which kinetic processes and non-Maxwellian distribution functions may play key roles. These situations include formation of toroidal O^+ distributions along field lines subjected to strong convection, the transition region where collisions are important but not dominant, and the formation of conics and other distributions via wave-driven perpendicular ion heating. In general, these treatments have not included coupling to the ionospheric production regions owing to the extensive computational time and storage demands involved in treating the lower altitude regions with GSK techniques. Recently, however, we have developed a new approach which utilizes a comprehensive moment-based approach for the altitude region $120 - 1100$ km joined to a GSK treatment for the 800 km-4 R_E altitude region. We call this approach Dynamic Fluid-Kinetic (DyFK) modeling. In this talk, we will describe recent results obtained with this approach, including the synergistic effects of soft electron precipitation, wave-driven perpendicular ion heating and hot plasma-driven potentials on the auroral ionospheric plasma transport.

S15-09

NUMERICAL SIMULATIONS OF MID-LATITUDE IRREGULARITIES

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Ionosphere F region is a very important medium for radio wave propagation while it is also the most changeable and most anomalous. Among all anomalies, spread-F is a well-known phenomenon and has drawn much attention of the researchers since it was found in 1937. This paper, a generalization of the model from equatorial region to mid- and low latitudes, both theoretical deduction and numerical simulations is presented. It is indicated that the controlling role of the geomagnetic configurations, including the field strength, inclination and declination can sometimes not be neglected. Due to different geomagnetic configurations, occurrence frequency of spread-F is no longer symmetrical for areas with same latitudes, even along the equator. Using this model, the role of gravity waves and their combinations with the horizontal or vertical gradients of background electric field as complicated seeds is discussed in detail. It is also showed that when the inhomogeneous neutral wind exists, the wave-like structure generated by some initial perturbation will be distorted. In mid-latitude, when horizontal neutral wind and gravity waves both exist, the plume-like structures generated are asymmetric for gravity waves propagated eastward and westward. A comparison of the bubble size generated in equatorial regions and in mid-latitude regions showed that in mid-latitude regions, gravity is more effective and the bubble size there is larger.

S15-10

KINETIC THEORY OF FIELD-ALIGNED ELECTRIC FIELD AND CURRENT

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Kinetic effects of particle dynamics along field lines and finite ion Larmor radii (FLR) are important in determining magnetic field-aligned electric field and current and thus affecting the wave propagation and plasma stability in low frequency (less than ion cyclotron frequency) phenomena. The physical mechanism depends on the wave phase speed along **B** in relation to the electron and ion thermal speeds. Typically, electrons move much faster and ions move much slower than the parallel wave phase speed. Moreover, electron motion across magnetic field lines is very different from ion motion if the perpendicular wavelength is on the order of ion gyroradii. The difference in gyro-averaged electron and ion motion across **B** causes charge separation. In order to maintain the charge quasi-neutralty a magnetic field-aligned electric field is produced to accelerate (or decelerate) electrons to different positions where there is excess positive charge. A field-aligned electric field can easily accelerate (or decelerate) untrapped electrons to change its density distribution. However, it is relatively harder to change the trapped electron density distribution by a parallel electric field because of their rapid bounce motion along the field lines. Thus, if the trapped electron population dominates as in the closed field line region of the magnetosphere, an enhanced parallel electric field will be produced to move electrons to maintain charge quasi-neutralty. The large parallel electric field will then drive an enhanced parallel current which can greatly increase the stabilizing field line tension over the value expected from the MHD theory. This physical mechanism is employed to understand the Alfvén waves and kinetic ballooning mode and their implications for substorm onset and particle acceleration in the auroral region.

S15-11

FLUID MODELIZATION OF COLLISIONLESS PLASMAS: A NEW CLOSURE EQUATION

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In collisionless plasmas, the large and short scale phenomena are generally connected in such an intricate manner that they cannot be safely separated (see for instance the question of reconnection in magnetospheric substorms). Unfortunately, because of the computer limitations, one is generally lead to make a choice whose consequences are difficult to estimate. One can use: 1) a good local microscopic description but with an approximate connection with the large scale boundary conditions (Vlasov or PIC simulations) or: 2) a good description of the global geometry but with an approximate description of the microscopic physics (MHD or multi-fluid simulations). Hybrid simulations are a compromise solution between both approaches. In the frame of the second approach, we will first investigate, from a theoretical point of view, what are the conditions for a fluid description to be valid. We will determine what are the truly kinetic phenomena, *i.e.* those that cannot be described with a finite number of macroscopic moments. Resonance phenomena will be distinguished from the easier question of finite Larmor radius effects. Finally, we will show that two main cases fall within the range of fluid effects: the purely temporal variations (spatial variations negligible during one characteristic time for the thermal particles) and the opposite limit. The first case leads to an adiabatic behavior first studied by *Chew, Goldberger and Low* (1956), and we will show that a more general law can be derived in this adiabatic case). The second case generally leads to an isothermal behavior. We will finally propose a new closure equation, approximately valid in both cases, *i.e.* for any kind of fluctuations when no resonance is at play. The next step will be to implement this closure equation in an hybrid code.

S15-12

KINETIC MODELS FOR THE PARALLEL E FIELD IN AURORAL REGIONS

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In inhomogeneous, magnetized space plasmas, there are several ways to produce a magnetic field-aligned electric field. In this paper, we examine two mechanisms: velocity-space anisotropy and anomalous transport effects. In a turbulent plasma, we give a stochastic, semi-empirical formulation of the problem based on a system Fokker-Planck equations and the quasi-neutrality condition. Two cases are examined: upward and downward auroral-current regions. In upward auroral-current regions, upward flowing ion beams, precipitating electrons and broadband ELF (BBELF) are often observed. We show that an upward pointing, parallel E field and a potential decrease of several kilovolts from the ionosphere to the inner magnetosphere can occur. In downward auroral-current regions, intense ion conics, upward flowing field-aligned electrons and BBELF are often observed. In this case, we show that a downward pointing, parallel E field and a potential increase of up to one kilovolt from the ionosphere to the inner magnetosphere can occur. In each case, the conservation laws derived from the kinetic equations place powerful constraints on the moments of the ion and electron distribution functions and the magnitude and direction of the parallel E field. The consequences of these conservation laws for each region are discussed.

S15-P01

THREE-DIMENSIONAL HYBRID SIMULATION OF SOLAR WIND INTERACTION WITH UNMAGNETIZED PLANETS

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The interaction between the solar wind and unmagnetized planets was investigated using computer simulation and a three-dimensional hybrid code that treats kinetic ions and massless fluid electrons. In the simulation the planet was treated as an ionized gaseous body with uniform and constant supply of plasma. The results given in this paper showed that the shock size and magnetic barrier intensity are asymmetrical in the direction of the convection electric field due to oxygen ions escaping from the side of the planet to which the electric field was pointing. The calculated asymmetry in the magnetic barrier intensity was consistent with observations, although the direction of the calculated asymmetry in the shock size did not match the asymmetry observed near either Venus or Mars. When the planet size was comparable to the Larmor radius of protons, a multiple shock structure was observed in the simulation. It is suggested that this structure is due to dispersion of the magnetosonic waves caused by the finite Larmor radius of protons. The simulation results also showed that ions escaped to the magnetotail through the tail rays and that the tail rays were connected with the plasma sheet.

S15-P02

A MESO-SCALE PARTICLE-IN-CELL SIMULATION MODEL FOR THE AURORA-IONOSPHERE SYSTEM

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Modeling of the aurora-ionosphere region poses a formidable challenge due to the great variation in length and time scales and the need to include multiple species and kinetic effects. We have developed a $2\frac{1}{2}$-D particle-in-cell simulation model which can address many of the physical processes in this region. The cold ionosphere is represented by a gravitationally bound plasma atmosphere with an exponentially decreasing density as a function of altitude. Additional particle species that can be included are a warm magnetospheric plasma and a narrow, cold electron beam that can be injected at either the top or bottom of the simulation region.

The initial version of the model is electrostatic and has been used to investigate electron beam generated solitary structures in a nonuniform plasma system. The density variation plays a crucial role in determining the nature of the hole structures that propagate away from the initial interaction region. For injection into a decreasing density (as in the downward auroral current region), the resulting bipolar structures remain coherent as they propagate into an increasingly more tenuous plasma. The robustness of these structures provides an explanation for the observed disparity in occurrence of the bipolar structures between the upward and downward auroral current regions.

The model is being extended to include electromagnetic effects through a Darwin approximation in which only the parallel component of the vector potential is retained. This extended model is being used to investigate the role of Alfvén waves and plasma sheet polarization in producing inverted-V auroral arcs.

S15-P03

FORMATION OF ELECTROSTATIC SOLITARY WAVES IN KINETIC SIMULATION MODELS WITH OPEN BOUNDARIES

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We present computer simulations of electrostatic solitary waves (ESW) observed by the Geotail spacecraft in the Earth's magnetotail. Simulation studies in periodic systems show that ESW are generated by electron beam instabilities. In the periodic systems, unstable velocity distribution functions are assumed to exist uniformly in space, however, there exists no uniform system in real space plasmas. In an open system we adopted, a cold electron beam with very low density is injected locally from the boundary through warm background electrons. In a one-dimensional system, a series of electrostatic potentials are generated through the nonlinear evolution of bump-on-tail instability. As the electron beam propagates along the static magnetic field, these potentials coalesce with each other and become isolated. The spatial scales of the solitary potentials and its distance between them become larger depending on the distance from the source region of the electron beam. In the one-dimensional simulation, we cannot see any effect of ion dynamics, though both electron and ion motions are solved. In the present study, we also adopt a two-dimensional half-open system that has open boundaries in the direction parallel to the static magnetic field. Simulation studies in two-dimensional periodic systems show that cyclotron motion of ion affects the two-dimensional structure of potentials. Strong quasi-perpendicular lower hybrid waves are excited uniformly in space through a coupling of drift velocities of potentials and parallel phase velocities of lower hybrid waves. In the open system, on the other hand, generations of ESW are localized in space and lower hybrid waves propagate slowly in parallel to the static magnetic field. Therefore, it is expected that the interaction between ESW and lower hybrid waves as observed in the periodic system takes place in a localized region of the open system.

S15-P04

THE ROLE OF ELECTRONS IN MAGNETOTAIL DYNAMICS

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The role of electrons as current carriers in the magnetotail under both quiet and disturbed conditions has recently been the subject of much debate. Ion currents are thought to dominate in the cross-tail direction. However, in regions of weak magnetic field, electrons may carry substantial current, which due to their small inertia, may quickly be adjusted to a varying magnetic field geometry. In this study, we investigate the role of electrons in determining magnetotail dynamics by using self-consistent large-scale kinetic simulations of the tail. In these calculations, the magnetotail is continuously populated by ions from the plasma mantle and the magnetic field is updated from the electron and ion currents by using the Biot-Savart law. While ion currents are determined directly from the particles, electron currents are modeled by using a Boltzmann approximation in the parallel direction and by the transverse portion of the guiding center equations perpendicular to the magnetic field.

S16-01

STUDYING DYNAMICS IN THE ARCTIC AND SUB-ARCTIC MESOSPHERE USING MF AND INCOHERENT SCATTER RADAR

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Determination of winds in the mesosphere and lower thermosphere using radar systems is common practice. However the extents to which dynamics may be studied at extremes of scale-size, and with which kind of radar technology is not so well appreciated. Here, we shall review how successfully different scales of dynamics may be determined, and how suitable MF and incoherent scatter radar systems are to these tasks. The treatise will be illustrated by examples of observations made from the sub-Arctic Norwegian mainland and from Svalbard in the Arctic. In particular, we identify the need to operate more than one radar system at any given location. Two of the reasons for this are that: any observation must be evaluated in the context of a longer term observation to determine whether or not it is pathological, and (b) any measurement technique should be validated by another method or methods.

S16-02

GEOMAGNETIC ACTIVITY EFFECTS IN THE LOWER THERMOSPHERE

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We investigate the effects of geomagnetic activity in the lower thermosphere using the National Center for Atmospheric Research (NCAR) thermosphere-ionosphere-mesosphere-electrodynamics general circulation model (TIME-GCM). TIME-GCM is a first principles, three-dimensional, time-dependent model of the Earth's atmosphere between about 30 and 500 km. It is based upon an aeronomic scheme for the coupled thermosphere-ionosphere system that was extended to include the physical and chemical processes appropriate for the mesosphere and upper stratosphere. TIME-GCM calculates the self-consistent solutions of the coupled, nonlinear hydrodynamical, thermodynamical, and continuity equations with compositional coupling and electrodynamics. We report on the large-scale dynamical features for select simulations which include sustained periods of geomagnetic activity. We characterize the competing effects of upward propagating tides and downward penetrating geomagnetic storm signatures. We compare the model results with choice Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR) and Upper Atmosphere Research Satellite (UARS) observations. Finally, we discuss the geomagnetic response and recovery of the lower thermosphere in the context of underlying ion-neutral coupling processes.

S16-03

COMPARING ENERGETIC AURORAL PRECIPITATION AS OBSERVED BY PIXIE AND NITRIC OXIDE OBSERVED BY SNOE

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We examine in this study bremsstrahlung observations from the entire north polar region as observed by the POLAR Ionospheric X-ray Imaging Experiment (PIXIE) instrument on board the NASA/GGS POLAR spacecraft, and compare with resonantly scattered UV observations from the ultraviolet spectrometer on board the Student Nitric Oxide Explorer (SNOE) spacecraft. The bremsstrahlung emissions are the result of energetic electrons (> few keV) precipitating into the auroral regions. The energetic electrons deposit most of their energy at approximately 100 – 110 km altitude. From a high-altitude orbit (about 9 Earth radii at apogee) PIXIE provides a global picture of the intensity of precipitation of energetic electrons. This is particularly relevant for the production of nitric oxide (NO), an important trace element in upper atmospheric ozone chemistry. The UV instrument on board SNOE (altitude of 556 km) observes resonance scattering from NO, providing an estimate of NO density between 90 and 170 km altitude. A comparison of these two sets of observations over the course of a year reveals that the high-latitude precipitation of energetic particles from the magnetosphere is well correlated with variations in the density of NO at auroral latitudes, which persist for many hours. In this study we compare the overall temporal and spatial variation of the two distinct data sets. The results demonstrate an important way of understanding upper atmospheric effects of magnetic storms using remote sensing at different wavelengths, and contribute to our understanding of the chemical coupling of solar activity through the magnetosphere to the upper atmosphere.

S16-04

FEATURES OF THE TIMED DOPPLER INTERFEROMETER (TIDI) OPERATIONAL SCIENCE MODES AND DATA PRODUCTS

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The TIMED Doppler Interferometer (TIDI), one of four instruments aboard the TIMED satellite, is a single-etalon Fabry Perot interferometer designed to measure winds, temperatures, and minor constituent densities in the mesosphere and thermosphere. The launch of TIMED is expected to take place in early 2001. We will describe the routine dayside and nightside observations, and the adjustment of these routine modes for the special condition when the satellite ground track skirts the day/night terminator, splitting the two measurement tracks between day and night. The overall spatiotemporal coverage of the data set and the altitude range over which each atmospheric emission is observed will be reviewed.

The inversion algorithm and data processing flow have been designed to preserve maximum information content while creating a flexible and user-friendly set of end data products. The design philosophy and special features of the approach taken to data inversion will be discussed. An overview of the standard data products will be given to familiarize the end user with the contents of the data files at each level of the data. All processing levels of the data will be made readily available to the research community via a convenient web site cataloging and ftp ordering system. This presentation will be most informative for anyone considering use of the TIDI data set in their scientific studies.

S16-05

MEAN WINDS AND WAVES IN THE UPPER MIDDLE ATMOSPHERE OBSERVED BY POKER FLAT MF RADAR (65.1 N, 147.5 W) IN 1998 – 2000

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An MF radar at Poker Flat (65.1N, 147.5W) has been operated since October 1998 by an international collaboration between Communications Research Laboratory, Japan and Geophysical Institute, University of Alaska, U.S.A. MF radar observations of mean winds, tides, and planetary-scale waves in the upper middle atmosphere are presented. Amplitudes of semidiurnal oscillation show strong seasonal variations and largest around 90 km height during February–March and September–October 1999. The phase variability of the diurnal and semidiurnal tide seems to be more stable in the summer time rather than one in the winter time by the Poker Flat MF radar observations from October 1998 to October 1999. This suggests that a strong coupling of mean winds, tides and gravity waves affects the feature of tidal variability at high latitudes. Planetary wave activities enhanced during winter season are also presented.

S16-06

INVESTIGATION OF CORRELATED TERDIURNAL OSCILLATIONS IN OH MEINEL (6,2) BAND INTENSITIES AND ROTATIONAL TEMPERATURES AT MID-LATITUDES

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During the past three decades, a number of experimental and theoretical studies of fluctuations in the terrestrial nightglow intensities and rotational temperatures have established internal gravity waves, planetary waves, and tides as the dominant sources of coherent oscillations in the mesosphere and lower thermosphere region ($\sim 80 - 100$ km). A principal objective of these studies has been the determination of the Krassovsky ratio "eta" a complex parameter relating the amplitudes and phases of the oscillations in intensity to those in temperature. However, despite numerous refinements to sophisticated models there are still significant incompatibilities between the measured and predicted values of eta suggesting deficiencies in the models. The CEDAR Mesospheric Temperature Mapper (MTM) is a sensitive new instrument that was designed to investigate wave-induced variability in OH M(6,2) intensity and rotational temperature at the $\sim$ 87 km level with a precision of better than 2 K in 3 min. Measurements have been made from three mid-latitude sites: Bear Lake Observatory, UT (42 N), Ft. Collins, CO (41 N), and most recently from the Starfire Optical Range, NM (35 N), USA. These observations have revealed a wealth of coherent wave motions in the period range ($>$ 10 min – 10 hr) including marked terdiurnal oscillations in the temperature and intensity field. This talk will review our current knowledge of the data-model disparities and will present new data on the observed amplitudes and phases of long period, $\sim$8 hr, oscillations to help understand this outstanding problem.

S16-07

STUDYING MESOSPHERE DYNAMICS IN THE ANTARCTIC USING THE UPGRADED INSTRUMENT CLUSTER AT HALLEY

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March of this year saw the commissioning of an Airglow Imager at Halley, Antarctica by the British Antarctic Survey and Utah State University. This represents an additional tool in our ability to study the dynamics, energetics, and electrodynamics of the region extending upwards from the mesosphere into the upper thermosphere/ionosphere. Halley is ideally placed to investigate forcing of solar, magnetospheric and orographic origin, before the energy and momentum dissipated goes on to affect the global ITM system through altered global circulation, and changed thermal and chemical responses. We will present results from multi-instrument campaign activities in this first year of operation. In particular we will focus on periods of 24-hour airglow data coverage made possible by the high latitude of the station.

S16-08

IDI MEASUREMENTS OF MESOSPHERIC DYNAMICS FROM THE BEAR LAKE OBSERVATORY

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The application of Imaging Doppler Interferometry (IDI) to the NOAA dynasonde deployed at the Bear Lake Observatory in northeastern Utah enables the routine measurement of mesospheric dynamics. Influenced by the direction of the prevailing wind, a clear seasonal variation is seen in the mesospheric echo numbers. The technique also provides a monitor for the amplitude of the main tidal modes as well as for studying planetary waves with periods from 2 – 20 days. The observations are found to be consistent with those from different instruments based at the same site thus confirming the IDI characterisation of the mesospheric wind field.

S16-09

WAVES IN AIRGLOW STRUCTURES EXPERIMENT 2000: PRELIMINARY RESULTS AND INTERPRETATIONS

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Coordinated measurements of the waves in airglow structures (WAVE2000 Campaign) by rocket-borne and ground-based instruments was carried out at KSC (Kagoshima Space Center; 31N, 131E) on 10 January 2000. The main purpose of the campaign is to answer the question 'Is our understanding about the formation process of the waves in airglow structures correct?'. Another purpose is to check the validity of the ground-based triangulation to estimate the height of the airglow layer. One of the unique points of this campaign is to measure atomic oxygen density [O] by an in-situ method on board the rocket as well as to measure airglows. In spite of its important role in the airglow process to provide the energy source, its density structure has poorly been examined with the ground-based imaging of the waves in airglow structures so far. The present campaign expects new findings by combining the horizontal information by the ground-based instruments and the vertical information by the rocket-borne instruments. The rocket S-310-29 was launched to measure the followings (1)–(4): (1) [O] at 70 – 180 km by the resonance lamp method. (2) OH , O2A band and Green line airglows at 70 – 110 km by filter photometers. (3) electron density at 70 – 180 km by the probe method. (4) wind at 80 – 100 km by the chaff method. The ground-based measurements were as follows (5)–(7): (5) all-sky imaging of the OH, O2A band and Green line airglows at KSC, Yamagawa (44 km west of KSC), and Ohsumi (40 km north of KSC). (6) wind measurement by the MF radar at Yamagawa. (7) OH rotation temperature measurement at KSC. In addition, the MU radar wind measurement was carried out simultaneously at Shigaraki located 500 km north-east of KSC. Preliminary results and interpretations will be discussed.

S16-10

SEASONAL VARIATIONS OF SOLAR TIDES, PLANETARY AND GRAVITY WAVES IN THE MLT: MULTI-YEAR MFRADAR OBSERVATIONS FROM 2 – 70 N AND MODELLING COMPARISONS

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Continuous observations of the MLT have been made by 7 Medium Frequency Radars (MFR) located between the equator and the high northern latitudes: Christmas Island 2 N, Hawaii 22 N, Yamagawa 32 N, Urbana 40 N, London 43 N, Saskatoon 52 N and Tromsø 70 N. Data have been used for the STEP years of 1990 – 1997, with 5 years being typically available from each site. A variety of analysis methods have been used to obtain the signatures of solar tides, planetary and gravity waves. For the tides, this is the largest comparison of observations with models since the years of MAP. Observations have increased in coverage since then, and clear latitudinal variations emerge. The comparisons with the much improved (complexity) models are now extemely good for the 24 hr tides; the 12 hr continues to be a challenge for the models. Clear observed patterns for the Planetary Waves, in particular the largest (16 d) wave, also emerge, with both winter and summer occurences. Models are in fair agreement, although their sensitivity to changes in the background fields are not always adequately defined. The observed Gravity Wave fluxes show strong Doppler effects, latitudinal changes, and monthly and seasonal variations. Of note is the finding that regional changes over 500 km may be as great as differences over 10 – 25 degrees of latitude. Comparisons with models is best done using GCMs, and output data from the Canadian CMAM in the Gravity Wave portion of the spectrum will be shown for the first time. This is crucial testing of the parameterizations used in such models, which strongly depend upon those for the production of realistic dynamical fields for all atmospheric waves.

S16-11

MF RADAR OBSERVATIONS OF MESOSPHERE LOWER THERMOSPHERE TIDAL WINDS OVER YAMAGAWA AND WAKKANAI

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MF radar observations at Yamagawa (31.2 N, 130.6 E) and Wakkanai(45.4 N, 141.7 E) are progressing on a continuous basis. Using 3 years of wind data we have carried out a systematic analysis on the structure/variations of atmospheric tides over these locations. Data from these 2 sites help to study the latitudinal dependence of tidal parameters. Comparison of tidal amplitudes indicates that the diurnal tidal amplitude at Yamagawa is consistently larger than that observed at Wakkanai. Semidiurnal tidal amplitudes are roughly of same strength at both sites. Tidal amplitude and phase profiles are further compared with those of the Global Scale Wave Model (GSWM-98). There are interesting similarities as well as certain discrepancies.

S16-12

MULTI-RADAR OBSERVATION OF IONOSPHERIC E-REGION IRREGULARITY

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The quasi-periodic (QP) echo is a type of echo produced by field-aligned irregularities (FAI). These echoes are characterized by wavelike structures when displayed in the range-time intensity (RTI) plot. Knowledge of spatial structure is very important to understand the generating mechanism of the QP echoes. While their horizontal structures were studied by using multi-beam observations, it was not easy to distinguish their true height structure from RTI plots of a single-radar experiment. In August 1999, we conducted the first two-radar observations of the E-region FAI over California. In this experiment we operated two FAR (Frequency-Agile Radar) systems, one located at Stanford (37.4 N, 122.2 W) and the other at Pleasanton (37.7 N, 121.9 W). The distance between these sites were approximately 40 km. The FAR at Stanford was operated as a monostatic radar at 24.5 MHz while the FAR at Pleasanton was operated to receive the transmission from Stanford. Both systems were synchronized by using GPS-locked reference signal generators and were operated to receive echoes simultaneously. From cross-correlation analysis between RTI distributions of two radars, it was found that QP echoes have height structures which were elongated along the geomagnetic field-line, and propagated horizontally. The other two-radar experiment will soon be available in Japan by using two VHF radars installed in Shigaraki and a nearby location. New results from these observations including comparisons with the MU radar are shown in the presentation.

S16-13

GENERATION OF ATMOSPHERIC GRAVITY WAVES AND ENERGY BALANCE IN THE IONOSPHERE DRIVEN BY STRONG ELECTRIC FIELDS

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The major energy source and driving force for thermospheric modifications following magnetic disturbances is widely accepted to be ohmic heating by the imposed electric field due to ion-neutral drag. This mechanism yields a relatively slow, > 30-min time-scale, thermospheric response. Recent observations of 10 to 20-min period atmospheric gravity waves (AGW) associated with short (a few min) periodically recurring enhancements of the electric field indicate that the thermosphere can respond much faster than usually expected. Such short periodicities cannot be explained in terms of the ion-neutral drag, unless the electric field in the E region achieves > 280 mV/m, which is unlikely. Therefore, an additional source of energy transfer to neutral gas is needed. A scenario is presented where anomalous heating due to the Farley-Buneman (FB) instability driven by strong electric fields plays the key role. Indeed, numerical modeling of chemical transformations in the auroral thermosphere shows that the temperature of non-equilibrium neutral gas may grow significantly within about 10 min due to fast vibrational-transitional exchange and chemical reactions. This requires that strongly heated, > 2800 K, ionospheric electrons be present. The necessary heating rate is far beyond the limits of collisional heating, however, it can be maintained by strong FB turbulence. Radar observations showing elevated, 2500 K to 3000 K, electron temperature correlated with enhanced FB waves support such a scenario.

S16-14

MEASUREMENTS OF ELECTRON DENSITY ALTITUDE PROFILES AND ESTIMATION WIND VELOCITY IN THE UPPER ATMOSPHERE FROM RADIO OCCULTATION DATA

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Wave phenomena in the upper atmosphere can be studied using high-precision GPS/MET radio navigational fields. Basic principles, accuracy and vertical resolution of radio holographic technique for studies of ionospheric wave phenomena are presented. The radio holographic method allows accurate determination of vertical profiles of the electron density in D-and E-layer region (including valley zone) and monitoring various kind of wave motion in the upper atmosphere using GPS/MET radio occultation data. As an example of this approach, observations of the summer Antarctic mesosphere on 07 February 1997 are presented. Vertical resolution of $0.3 - 0.5$ km reveals wave-like structures with spatial periods from $1 - 2$ km to 8 km and amplitudes $2000 - 8000$ electrons per cubic centimetre in the vertical electron density distribution in the D-and E-layers at the altitudes of $72 - 110$ km. These wave-like structures are important for understanding the role of gravity waves and their contribution to the dynamic of the summer Antarctic mesosphere. The structures in the electron density distribution may be connected with neutral horizontal wind velocity altitude profiles. Quantitative theory is developed that connected parameters of horizontal wind velocity altitude profile with observed electron density altitude profile. Maximums in electron density distribution correspond to minimum neutral horizontal wind velocity values, thus determining vertical positions of wind shears in the upper atmosphere. Correspondence of the derived theory to experimental rocket measurements of electron density distribution is shown. As it follows from analysis the application of radio holographic method for revealing ionospheric information using data obtained from radio occultation measurements seems to be perspective for observing natural processes in the upper atmosphere.

S16-15

A COMPUTER SIMULATION OF IONOSPHERE–THERMOSPHERE COUPLING AND COMPARISON WITH SATELLITE OBSERVATIONS

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The interaction process between neutral atmosphere and ionosphere in the planetary thermosphere is controlled by planetary intrinsic magnetic field and the difference in directions of gravitational force and magnetic field line. The interaction is also controlled by electric fields and neutral winds such as general circulation and gravity waves generated by aurora and propagating from lower atmospheres.

To understand the physical interaction process of ionosphere with neutral atmosphere in the thermosphere, we developed a coupled global ionosphere - thermosphere model and compared the simulations with satellite observations. Our model includes accurate calculations of F layer's ion/electron densities and temperatures with photoelectron flux and heating calculations. We are able to carry out the simulations to investigate the effects of gravity waves and TID. The simulation results show that electron/ion temperatures change with plasma density variations generated by gravity waves or TID and the temperature change differs in latitude. We obtained good agreements between simulations and observations. Our model may be applied as a tool of space weather forecast.

S16-16

TRAVELING IONOSPHERIC DISTURBANCES AND BAND-LIKE STRUCTURES OF F-REGION FIELD-ALIGNED IRREGULARITIES (FAI) IN MID-LATITUDE IONOSPHERE

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The MU radar at Shigaraki (34.85 N, 136.10 E) observes huge plume-like structures of F-region field-aligned irregularities (FAIs) in summer during solar minimum periods. The plumes show marked upwelling structures with large Doppler velocities up to 200 m/s. The plumes aligned in band-like shape are studied based on multi-beam observations of the MU radar. It is found with these observations that the plumes are generated, almost always, in the bottom side of the ionospheric F-region, with some penetrating the F-region peak height. The structure is well correlated with passage of traveling ionospheric disturbances (TIDs) which are simultaneously observed with GPS. A detailed investigation of the echoes on June 12, 1995 show that the band-like structure spatially elongates from northeast toward southwest, and propagates southwestward with the phase velocity of 145 m/s. Averaged Doppler velocity of the echoes is northwestwards with the speed of 77 m/s, which corresponds to the northeastward electric field of 3.2 mV/m. The relationship between the propagation direction and the electric field is favorable for the generation of Perkins instability. From all multi-beam observations in 1995 – 1997, band-like structures are found in ten cases. They show west-southwestward phase propagations, 10 – 30 minutes of periodicity, and 100 – 200 km horizontal wavelength. Electric fields estimated from the Doppler velocities are all directed northeastward with the range of 2.4 – 6.4 mV/m. The thermospheric wind data are not available with the MU radar observations, but an average polarization electric field due to the HWM is northeastward during this period. This relationship reveals that the Perkins instability is the probable candidate to generate the F-region plumes.

S16-17

HALL-MHD SIMULATIONS OF IONOSPHERE-MAGNETOSPHERE COUPLING

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Using a Hall-MHD code with an ion-neutral friction term as well as ionization and recombination terms we study scenarios of ionosphere-magnetosphere coupling. The friction in the bottom part of the simulation box, representing the ionosphere, produces magnetic stresses and field-aligned currents that act back on the plasma in the top part of the box representing the magnetosphere. By specifiying the magnetospheric plasma velocity as boundary condition the simulation reaches after a transient dynamic phase a steady state where energy and momentum is constantly transfered from the magnetosphere to the ionosphere.

We find that the plasma flow in the lower ionosphere becomes compressible, and consequently the plasma density varies horizontally even for horizontally constant ionization rate. This effect is more pronounced for small scale structures than for larger scales. Observations of density variations have usually been attributed to particle precipitation causing additional ionization, neglecting the horizontal transport effects on which this simulation focuses. Concerning MI-coupling the varying density constitutes a non-uniform load for the magnetosphere and modifies the magnetic stress and field-aligned current distribution.

S16-18

REAL-TIME MODELING OF THERMOSPHERE/IONOSPHERE SPACE WEATHER USING THE TING GENERAL CIRCULATION MODEL

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The TING (Thermosphere/Ionosphere Nested Grid) model, a nested grid/general circulation model, has been running nearly continuously in real-time as a "now-cast" and "forecast" Space Weather capability for global thermosphere-ionosphere specification for six months, starting in November 1999 to the present. The results of these runs are routinely published on the world wide web at http://sparc-1.si.umich.edu/sparc/central. Because the Space Physics and Aeronomy Research Collaboratory (SPARC) system also displays real-time output from running Incoherent Scatter Radars, ionosondes and satellite and much other data, it is possible to make an assessment of the opportunities and difficulties in running the model in this mode. The initial results of this work show that the difficulties fall into two broad categories: 1) operational problems, such as computer outages and 2) problems with the physical and chemical schema used in the model. The initial comparisons between the real time data streams and the model predictions are encouraging, though additional work is needed to develop skill indices and to optimize the input model parameterizations. This paper will summarize the development of the real-time operational GCM and will present the results of the initial data validation tests.

S16-19

THE INFLUENCE OF HIGH-LATITUDE ELECTRIC FIELDS ON THE DYNAMICS OF THE LOWER THERMOSPHERE

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High-latitude ionospheric electric fields and currents are an important driver of thermospheric dynamics through ion drag and Joule heating. Observations and numerical simulations of high-latitude thermospheric winds during disturbed periods show that the large-scale wind distribution is significantly altered at least down to altitudes of 115 km on a time scale of hours or less. The observed disturbance wind patterns are analyzed in relation to the observed ion-drift patterns to obtain quantitative estimates of the dynamical forcing due to ion drag and Joule heating as functions of altitude and magnetic activity level.

S16-20

FEATURES OF THE SEASONAL VARIATION OF GLOBAL GEOMAGNETIC SQ FIELD

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Features of the seasonal and UT variation pattern of geomagnetic Sq field was examined using the equivalent Sq current system in 1964 and 1980 – 1984. It was found that there are two types in the UT variation of the current intensity in the northern hemisphere. One is semi-diurnal and found from May to Sep. and the other is diurnal and found from Nov. to Feb. This feature appears in the all years and seems to be caused by the seasonal variation of conductivity wind. This is partly due to the inaccordance of geographic and geomagnetic axes, but may be related with the seasonal variation of the current system itself. At 00 – 04h UT, there are only two types in the global equivalent Sq current system in one year. That is "summer type" and "winter type" and there is no "equinox type". The transition from "summer type" to "winter type" is fairly abruptly in the first half of October.

S16-21

DYNAMICAL COUPLING BETWEEN NEUTRALS AND IONS IN THE AURORAL E-REGIONS VERIFIED BY SIMULTANEOUS FPI AND VHF RADAR OBSERVATIONS

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In order to clarify the relationship between neutrals and plasmas in auroral E-region, we have analyzed neutral wind and plasma drift data obtained simultaneously by a Fabry-Perot Doppler Imaging System (FPDIS) and a VHF radar, respectively, installed at Syowa station (66.4 deg. MLAT), Antarctica. Line of sight velocities of neutral winds in the E-region covered by the VHF radar were obtained from FPDIS 557.7 nm observations by setting the field-of-view poleward with a slant objective mirror (FOV= 42 deg.). On the other hand, we estimated E-region plasma ($\boldsymbol{E} \times \boldsymbol{B}$) drifts from the Doppler velocities of electron density irregularities obtained by the VHF radar. From case studies for 3 nights, we obtained following results. For large-scale variations with a time constant more than 1 hour, it is inferred that plasma drifts were driven by electric fields penetrated from the magnetosphere since the directions of plasma drifts were consistent with those of the 2-cell convection pattern. For small-scale temporal variations with a time constant less than 1 hour, velocity variations of neutral winds agree well with those of plasma drifts. In the E-region, since the neutral-ion momentum transfer collision frequency ($\sim$ 0.01 sec) is much less than the ion-neutral momentum transfer collision frequency ($>$ 1 day), it is obvious that those temporal plasma drifts were driven by neutral-driven electric fields, which were generated by neutral-ion collisions. From the velocity ratio between large-scale and small-scale plasma drifts, it is suggested that the ratio between the magnetospheric electric fields and the neutral-driven electric fields was approximately 3.

S16-22

COMPARISON OF THE AURORAL E REGION NEUTRAL WINDS DERIVED BY THE EISCAT RADAR AND PREDICTED BY NCAR TIME-GCM

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A comparison study of the auroral E region neutral wind is conducted using the European Incoherent Scatter (EISCAT) radar observations and Thermosphere-Ionosphere-mesosphere-electrodynamics general circulation model (TIME-GCM) predictions. Daily mean wind as well as diurnal and semidiurnal tidal winds are compared for three seasons such as summer, equinox and winter between 95 and 120 km. Fairly good agreement is found in an altitude profile of the mean zonal wind between the EISCAT observation and the TIME-GCM prediction for summer, which blows westward in the mesosphere and eastward in the lower thermosphere in the TIME-GCM predictions. This confirms the gravity wave (GW) plays a role in the dynamics in the upper mesosphere and lower thermosphere, and its parameterization used in the TIME-GCM is well developed. On the other hand, for winter, the zonal mean wind predicted by TIME-GCM never turns to westward in the lower thermosphere contrary to the EISCAT observation. This would be caused by a filtering effect due to winds in the stratosphere and mesosphere, which results in GWs having eastward momentum still existing in the lower thermosphere in the model. The meridional mean wind amplitude predicted by TIME-GCM is significantly smaller than that observed by EISCAT and slightly northward for all the seasons. Generally good agreement is found for diurnal tide, especially for the summer prediction. However, some discrepancies are found concerning phase profile. Semidiurnal amplitude predicted by TIME-GCM is much smaller than that observed by EISCAT. What are further necessary for TIME-GCM predicting more realistic winds will be discussed.

S16-23

VERTICAL WIND OBSERVATIONS IN THE THERMOSPHERE NEAR AURORA WITH FABRY-PEROT INTERFEROMETERS IN ALASKA

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Some characteristics of vertical winds in the polar thermospheric region are presented using datasets generated with two types of Fabry-Perot Interferometers at Poker Flat (65.11N, 147.42W), and at Eagle (64.78N, 141.16W), Alaska. The data were obtained during the winter season of 1998/1999 and 1999/2000 with the following results. (1) From observations of the OI630.0nm emission, upward (downward) vertical winds were often observed when bright aurora existed equatorward (poleward) of the observatory. This result is consistent with previous studies (*Crickmore et al.*, 1991; *Innis et al.*, 1996, 1997). (2) Comparison of vertical winds deduced from two different wavelengths (557.7 nm and 630.0 nm) shows that vertical winds were often observed simultaneously at both wavelengths, as shown in *Price et al.*, [1995]. However, some examples show that there are different features in the vertical winds observed at the different heights when thin but bright aurora passed over the observatory. A similar example is shown in *Ishii et al.* [1999]. (3) Vertical winds were often observed along with divergences and rotations of the horizontal wind field. Some vertical winds not associated with active aurora may be driven by the divergences in the horizontal wind. (4) In some cases the temporal variation of vertical winds are quite similar to that of H-component of magnetic field. It may be one of the evidence of close relation between vertical wind and ionospheric currents.

S16-24

ENERGETICS AND PLASMA DYNAMICS IN THE POLAR E AND F REGIONS

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The magnetosphere and ionosphere exchange energy in the form of electromagnetic energy fluxes accompanied by field-aligned currents and electric fields, particle fluxes or plasma waves. These energy inputs to the ionosphere from the magnetosphere drive ionospheric currents and most of the energy is eventually absorbed by the netural gas in the thermosphere. In this talk we will discuss characteristics of these energy couplings obtained from an analysis of the electromagnetic energy input, the Joule dissipation and the energy transfer to the neutral mechanical energy using European Incoherent Scatter (EISCAT) radar data. Special attention will also be given to field-aligned plasma motions between the ionosphere and the magnetosphere as well as between the E and F region.

S16-25

EFFECTS OF THERMAL EXPANSION ON NEUTRAL VERTICAL MOTIONS IN THE POLAR THERMOSPHERE

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In the polar thermosphere, vertical component of neutral winds have been observed with optical instruments such as Fabry-Perot interferometer (wavelength = 630 nm) at far greater speeds than predictions with global circulation models. There are, at least, two candidates for generation process of large vertical winds: thermal expansion due to auroral heating and divergent horizontal flow in the thermosphere. We focus on the effects of thermal expansion on vertical motions using European Incoherent Scatter (EISCAT) radar data. Substituting the electron temperature, the electron density, and the ion velocity vector from the EISCAT radar into the ion energy equation may provide neutral temperature and velocity vector fitting modeled values of the ion temperature into observed ones with the least square method. The neutral energy and continuity equations relate to the estimated vertical winds to thermospheric energy. The ionospheric energy due to frictional heating and direct heating caused by highly energetic electrons coming from the magnetosphere can be estimated using EISCAT radar data. If the estimated thermospheric energy is smaller than the ionospheric one, it is possible to create the vertical wind velocity through the thermal expansion. However, some estimated thermospheric energies were larger than the ionospheric ones. This suggests that not all vertical winds are created necessarily by thermal expansion thus the other processes exist.

S16-26

THE RELATIVE IMPORTANCE OF ELECTRIC FIELDS AND CONDUCTIVITIES IN THE AURORAL ELECTROJETS DURING SUBSTORMS

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The relative strength of ionospheric electric fields and conductivities in the substorm auroral electrojets has been examined. For this purpose, incoherent-scatter radar and magnetometer data are organized according to the substorm phases and the latitudinal location of the radar site within the auroral electrojet. It is found that the effects of substorm expansion, representing the unloading component of solar-magnetosphere coupling, are seen primarily in the equatoward half of the westward auroral electrojet in the morning sector. In the late morning sector, the directly-driven component, where electric fields are dominant, occupies the poleward half of the westward electrojet. In the premidnight sector,the division between these two components resulting from the two processes in substorm dynamics can be seen as the so-called Harang discontinuity, although the transition between these two are not very discontinuous. In the presentation, we discuss how the relative contribution of electric fields and conductivities varies during substorms.

S16-27

VARIATIONS OF THE ATOMIC OXYGEN GREEN LINE BRIGHTNESS ABOVE TIXIE BAY BEFORE SUBSTORM EXPANSION PHASE ONSET

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The comparison of photometric observations at the Tixie Bay station in January–March 1996 with data from magnetic network stations along 210 deg magnetic meridian has been carried out. It is shown that the brightness inhomogeneities in 557.7 nm emission are observed southward of the equatorial boundary of diffuse auroral luminosity in 630.0 nm emission. The analysis of optical structure dynamic changes depending on a substorm phase has been performed. Before the expansion phase onset whose center was formed at the observation meridian, the inhomogeneity drift directed to the south had the velocity $\sim 150 - 180$ m/s. During the substorm recovery phase with an epicenter in another longitudinal sector the drift velocity has been appeared to be several times smaller. Apparently, the detected velocity variations reflect the weakening character of convection electric field penetrating into the inner magnetosphere.

S16-28

THE EISCAT INCOHERENT SCATTER RADARS: PAST AND FUTURE ROLES IN IONOSPHERE-THERMOSPHERE-MESOSPHERE COUPLING STUDIES

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The EISCAT radars have been operating in Northern Scandinavia for nearly twenty years. The Association has recently completed both the EISCAT Svalbard Radar and a number of major upgrades to the original pair of incoherent scatter radars. The combination of the three EISCAT incoherent scatter radars, together with the wide range of other instruments deployed or observing in the vicinity, will support a new range of novel and effective observing strategies. We will review the instrumentation (present and planned) available in the high latitude European sector, with particular emphasis on facilities organised around the EISCAT incoherent scatter radars. The available EISCAT data sets, illustrated with selected highlights from past work, will be discussed. The future program, particularly those aspects relevant to Ionosphere-Thermosphere coupling studies, will also be described.

S16-29

BEHAVIOUR OF EQUATORIAL IONOSPHERE DURING SEVERE SPACE WEATHER EVENTS IN 1998

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All-sky observations of the F-region OI 630 nm nightglow emission enable us to visualize large-scale equatorial plasma depletions, generally known as transequatorial plasma bubbles. The OI 6300 imaging observations obtained at Cachoeira Paulista (22.7 S, 45.0 W; dip latitude ~16 S), Brazil, have been analyzed in conjunction with complementary ionospheric sounding, GPS and DMSP satellite measurements to study the response of the equatorial ionospheric region during three intense magnetic disturbances which occurred on August 26, September 24 and October 18, 1998.The analysis in the present study shows that large-scale ionospheric plasma depletions were initiated and evolved during the August and September magnetic disturbances (August and September are months when normally large-scale ionospheric plasma depletions do not occur in the Brazilian sector), where as the October magnetic disturbance acted as an inhibitor rather than creating conditions for generation of equatorial ionospheric plasma irregularities (during October month normally large-scale ionospheric plasma depletions are observed in this sector).

S16-30

NUMERICAL MODELING OF THE MAGNETIC STORM EFFECTS ON THE UPPER ATMOSPHERE FROM MESOSPHERE UP TO PLASMASPHERE

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We have used the global upper atmosphere model (UAM) to calculate numerically the response of the coupled Earth's mesosphere-thermosphere-ionosphere-plasmasphere system to the strong magnetic storm of 3 April 1979. The cross-polar cap electric potential drop has been estimated from the hourly AE index and solar wind parameters and served as the main model input parameter together with the empirical precipitating electron data. The calculated patterns of the winds, neutral mass density, temperature and gas composition as well as electron and ion density, drift velocity and temperatures have been analysed and compared with our previous numerical results obtained for the moderate magnetic storm of 25 January 1974 as well as with some observational data. Much more prominent LT-depending plasmapause dynamics has been noticed for the April 1979 magnetic storm in comparison with that of January 1974. The ion "hot zone" in the outer nightside plasmasphere has been obtained as a result of the contraction of the plasma during its electromagnetic drift. The contributions of the thermospheric winds and gas composition storm changes as well as those of the electric fields and geomagnetic field tube filling and depletion processes into the coupled storm dynamics of the ionospheric F2-layer troughs, light ion troughs and plasmapause have been considered. The height dependence of the neutral atmosphere disturbances has been analysed to investigate how deeply they can penetrate into the lower thermosphere and mesosphere during the magnetic storm.

S16-31

AURORAL AND AIRGLOW OBSERVATIONS USING ALL-SKY COOLED-CCD IMAGERS IN JAPAN DURING MAGNETIC STORMS (1998 – 2000)

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This presentation reviews observations of storm-related aurora and airglow for 1998 – 2000 using two cooled-CCD imagers at Rikubetsu (43.5N, 143.8E; geomag. 34.9N) and Shigaraki (34.8N, 136.1E; geomag. 26.6N). Sub-Auroral Red (SAR) arcs were observed at Rikubetsu on February 12 and May 13, 1999 and April 7, 2000. Southward-moving traveling ionospheric disturbance, which was identified as intense airglow emissions (about 300 R), was observed on September 15, 1999. Simultaneous observations of total electron content (TEC) using more than 1000 GPS receivers over Japan and ionospheric parameters using four ionosonde stations in the Japanese meridian, are available for these events.

S16-32

SEASONAL DEPENDENCE OF THE NIGHTTIME TRAVELING IONOSPHERIC DISTURBANCES IN THE MID-LATITUDE IONOSPHERE

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Seasonal and solar cycle dependencies of the characteristics of traveling ionospheric disturbances (TIDs) were studied with the total electron content (TEC) observations by GPS receivers and the 630 nm band airglow observations by all-sky CCD camera at mid-latitudes. GEONET (GPS earth observation network) in Japan have detected the medium-scale traveling ionospheric disturbances (MSTIDs) in the nighttime since 1997. The statistical analysis of the GEONET data between April in 1999 and April in 2000 revealed that the amplitude of these nighttime MSTIDs is largest in the summer solstice season, though the propagation direction of the nighttime MSTIDs is restricted to the southwest direction in all season. The all-sky CCD cameras at Puerto Rico and Hawaii observed the MSTIDs in the period from January 1997 to the middle part of 1998. The occurrence rate of MSTIDs detected by these all-sky imagers did not show clear seasonal dependency. The amplitude of the perturbation component of TEC has the second maximum around noon of winter. In this local time sector, southward traveling MSTIDs were often observed. The solar activity was found to effect on the amplitude of the nighttime MSTIDs. The ratio of the perturbation component of TEC to the background TEC is lower in the summer of 1999 than in the summer of 1998. Using the GPS data at mid-latitudes, the longitudinal and solar cycle dependencies of MSTID activity were studied to clarify the physical mechanism of the generation and propagation of MSTIDs.

S16-33

EQUATORIAL PLASMA FOUNTAIN AND ITS EFFECTS

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Following the suggestions of S. K. Mitra and D. F. Martyn, the equatorial plasma fountain was introduced in 1966 by W. B. Hanson and R. J. Moffett to explain the well known equatorial ionization anomaly (EIA). Though numerous studies of the low latitude ionosphere, which relate to the plasma fountain, have been carried out through experimental and theoretical modeling techniques, the fountain has received little attention.

In this paper we present the equatorial plasma fountain that covers nearly half of the global area as functions of local time, longitude, season and solar activity using the Sheffield University plasmasphere ionosphere model (SUPIM). Additional information are also added on some unique aspects of the low latitude ionosphere produced by the plasma fountain. A recently revealed additional layer in the equatorial ionosphere, called the F3 layer, produced by daytime plasma fountain can be observed by bottomside and topside soundings. The plasma temperature at the altitude of the F3 layer can decrease by as much as 100 K. A physical mechanism for the formation of the F3 layer observed by ground-based ionosondes has been reported. The sudden strengthening of the plasma fountain during evening hours and the subsequent nighttime cooling of the plasma give rise to an anomaly in plasma temperature in the topside ionosphere, called the equatorial plasma temperature anomaly (EPTA), observed by Hinotori satellite. Following the sudden strengthening, the fountain becomes somewhat like a reverse plasma fountain which contributes to the nighttime anomalous increases of plasma density at low latitudes. The fountain also causes the appearance of noon bite-out in peak electron density and its disappearance in total electron content (TEC). It is also shown that the equatorial anomaly in vertical TEC need not be as pronounced as the interpretation of the observations suggests.

S16-34

THERMOSPHERIC AND IONOSPHERIC DYNAMICS IN THE AURORAL REGION

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Structure and dynamics of the thermosphere and the ionosphere in the auroral region are quite complicated. There have been a number of reports on very strong vertical and horizontal neutral winds mainly in the auroral region. The magnitude of the vertical winds sometimes exceeds 100 m/s, but mechanism and consequence of such large winds have not been fully understood. Behavior of the ionosphere in the region with such neutral winds should be also complex. Although such variations are likely be confined into the polar region, those events are expected to produce equatorward propagating gravity waves. It is also possible that such phenomena influence the global structure and dynamics of the thermosphere-ionosphere system. Two- and three-dimensional thermosphere-ionosphere models are used to investigate small-scale but severe variations in the thermosphere and the ionosphere associated with auroral activities. The results are compared with ion and neutral winds measured by Fabry-Perot Interferometers and EISCAT. In this paper, emphasis is placed on the mechanism, influence, and predictability of severe thermospheric and ionospheric disturbances in the auroral region. Interaction processes between the global wind system and the locally generated winds are also discussed.

S16-35

ALL-SKY IMAGING OBSERVATIONS OF F-REGION AND MESOSPHERIC EMISSIONS

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An all-sky camera with 180 deg field of view was operated from Kolhapur (16.8 deg N, 74.2 deg E, dip lat. 10.6 deg N) in India on clear moonless nights during February and March 2000 to study the ionosphere-Thermosphere-Mesospherecoupling processes. During the period of February 2−8 and March 1−8, a good series of nightglow images were in OI 630 nm, 557.7 nm, 777.4 nm and 589.3 nm were obtained. A RG715 filter was also used to study the the atmospheric gravity waves. The observation period was generally quiet except for a period when a geomagnetic storm was in progress in February. During the period of observations, the solar flux ($F10.7cm$) was increasing continuously everyday by five to ten percent from its previous values (140 to 220 units). On most of the nights (40 − 50 percent of the total time) the OI 630 nm showed near north-south aligned intensity depletions which were moving towards the east. The results presented and discussed include (a) the characteristics of simultaneous plasma depletions observed in OI 630 nm, 557.7 nm and 777.4 nm and their relationship with spread-F and scintillation producing small-scale irregularities. (b) Signature of large scale size gravity waves and (c) zonal plasma drift velocity and bubble rise velocity at the equator as a function of local time. The eastward plasma drift speeds ($\sim$ 150 m/s) computed from bubble movement matches well with drift speeds computed from VHF scintillation experiment and Radar observation.

S16-36

PRE-PKU MODEL AND ITS APPLICATIONS

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Pre-PKU Model is a two-dimensional time-dependent hemispheric model for thermosphere-ionosphere coupling. It is composed with a Thermospheric Circulation Model in Meridian Plane (TCMMP) and a Time-dependent Ionospheric Model in Meridian Plane (TDIMMP). In TCMMP, thermosphere is treated as compressible, viscous fluid with momentum and energy sources and sinks, and thermal conduction. Starting from Navier-Stokes equations, densities, temperatures and velocities of five species, N_2, O_2, O, NO and CO_2, are calculated. Ionosphere is described by TDIMMP. Starting from Chapman's theory, solar radiation with wavelength less then 100 nm and 4 main photochemical reactions are considered in TDIMMP. Densities of O^+, NO^+, O_2^+, N_2^+ and electron as well as ion's velocity can be deduced.

Pre-PKU Model has been used to simulate the responses of upper atmosphere to some external disturbances like solar eclipse, magnetic storms, etc. Besides re-displaying those well-known response features, it is found that negligible thermospheric variations can sometimes enhance significant ionospheric disturbance. Simulations show that if it happens depends on the initial state of thermosphere.

S16-P01

QUASI 2-DAY WAVE IN THE MIDDLE ATMOSPHERE OVER YAMAGAWA AND WAKKANAI MF RADARS

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The wind data used are derived from Full Correlation Analysis of 2 MHz partial-reflection radar data obtained at Yamagawa (31 N, 130 E) and Wakkanai (45 N, 141 E) using the spaced-antenna technique. An oscillation with a period near 2 days is found in MF radar wind measurements made in the mesosphere and lower thermosphere at Yamagawa and Wakkanai. The 2-day wave oscillations are present in both meridional and zonal components. The oscillation is particularly strong in the meridional wind component, and seems to be present continuously in the $80 - 100$ km height region. The paper is also aimed to present the comparison of characteristics of two-day wave motions at these locations.

S16-P02

OBSERVATIONS AND MODELING OF AIRGLOW AND TEC FLUCTUATIONS INDUCED BY TRAVELING IONOSPHERIC DISTURBANCES

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Traveling ionospheric disturbances (TID), which are an ionospheric manifestation of atmospheric gravity waves (AGW), have been studied for a long time using various radio and optical methods. Although the knowledge of spatial and temporal structures of TID in the horizontal plane is necessary to clarify further the ionospheric responses to AGW and the characteristics of AGW, such observations have been very rare. Using an OI 630-nm all-sky imager at Shigaraki, Japan (34.85 deg. N, 136.10 deg. E) we detected a train of clear medium-scale TIDs on the night of May 22, 1998. On the two-dimensional images the TIDs (horizontal wavelength = 150 − 280 km, period = 30-50 min, and phase velocity = 80 − 90 m/s) had phase fronts along the NW-SE direction and propagated from NE to SW. Absolute airglow intensity enhancement above a background level of about 70 R attained 90 R when a bright airglow region passed over Shigaraki. Simultaneously we obtained total electron content (TEC) maps using a large number of GPS receivers distributed in the central area of Japan. These GPS-TEC maps also showed the same TID signatures (*i.e.*, TEC fluctuations due to the TID-associated F region electron density fluctuations) as observed on the airglow maps. The TEC fluctuations with periods of 20 − 50 min and peak-to-peak amplitudes of 1 − 4.5 TEC units (relative amplitudes of a few to 20) were almost in phase with the airglow fluctuations. Model calculations are needed to know a relation between altitude profiles of airglow and electron density and their height-integrated values (*i.e.*, airglow intensity and TEC to be observed on the ground). In this paper we use the SUPIM (Sheffield University Plasmasphere Ionosphere Model) model to obtain the airglow intensity and TEC, and then compare with the observations to find the most probable altitude profiles of the ariglow and electron density fluctuations induced by the TIDs. (Acknowledgments: The GPS-TEC data were supplied by the Geographical Survey Institute of Japan.)

S16-P03

SUBAURORAL LOWER THERMOSPHERE TEMPERATURE DURING STRATOSPHERE WARMING IN FEBRUARY 2000

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The behavior of lower thermosphere temperature is considered during stratosphere warming above Northeast Siberia in February 2000. The measurements of temperature were carried out by the new built Fabry-Perot spectrometer on a thermal broadening of emission 557.7 nm [OI] in moonless periods on optical station Majmaga near Yakutsk (63 N, 129.7 E). The spectrometer had the aperture of 140 mm and 1200 mm focal length telescope, free spectral interval is 0.0104 nm, instrumental width −0.0015 nm. The data on temperatures of stratosphere at levels 50, 10 and 2 mb were obtained from NOAA via the Internet.

A minor type stratospheric warming in January – February 2000 began on high altitudes and it obviously covered large atmosphere layer including lower thermosphere, a mesosphere and stratosphere and was spread downwards with decreasing amplitude. Temperature of lower thermosphere has increased in February approximately on 40 K (20) in a maximum of warming and was kept at least up to the end of February, though warming to this time already has disappeared, further temperature monotonically decreased up to minimum values of the observation periods about 110 K.

The temperature observation results display that the lower thermosphere warming has stopped at the end of February but in the meantime the second stratosphere warming was began. It is supposed, that from this moment the penetration of planetary scale wave disturbances in lower thermosphere became impossible that has resulted in its monotonic cooling with the intensity 8 K/day at absence of other additional sources of a thermal energy. These outcomes allow to make a conclusion that the planetary scale wave disturbances under certain satisfactory conditions can be spread up to lower thermosphere heights.

S16-P04

A STUDY OF THE NEAR MESOPAUSE TEMPERATURE BEHAVIOUR OVER YAKUTIA DURING 1998 – 2000 OBSERVATION PERIOD

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Results of the OH(6,2) and O_2(0-1) rotational temperature and intensity measurements at station Maimaga (63° N; 129.5° E) conducted during observation period of 1998 – 1999 and 1999 – 2000 are presented. A comparison of seasonal variation of the mean night rotational temperatures with atmospheric model CIRA-86 and MSIS-90 at the hydroxyl ($\sim$ 84 km) and molecular oxygen ($\sim$ 94 km) band excitation heights has been performed. It is shown that the experimental hydroxyl temperatures agree better with CIRA-86 model than MSIS-90 one. At the same time there are a significant deviations from model CIRA-86. For example, the hydroxyl rotational temperatures are systematically higher than model ones during February-March. The rotational temperature of oxygen molecular band has not a clear seasonal variation and does not agree with atmospheric models. The O_2(0-1) rotational temperatures are below than hydroxyl ones at all observation time. Discrepancy between them is minimal on autumn (August–October) and reaches maximum value in winter. The intensity of molecular oxygen emission like hydroxyl one depends on season and reaches minimum values on spring. The O_2(0-1) band is hardly visible in the nightglow spectrum at the end of April. Also there are temporal variations of both molecular bands parameters with a time scale from several days to two weeks. An analyses shows that a positive correlation exists between 10.7 cm flux and experimental data during January–March 1999 and anti-correlation exists during at the same month interval in 2000.

S16-P05

D-REGION WINTER ANOMALY OBSERVED WITH IONOSONDE AND MF RADAR

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With three ionosondes at Wakkanai (45.4N,141.7E), Kokubunji (35.7N, 139.5E) and Okinawa (26.3N, 127.8E) in Japan, a D-region winter anomaly event was observed between Jan. 11 and 18, 2000. There was no obvious decrease in the absorption enhancement with decreasing latitude, implying that the anomaly might extend to even lower latitudes than Okinawa. Electron density profiles were obtained for 76 – 80 km altitudes by the MF radar at Wakkanai. During the period of the winter anomaly, electron density clearly enhanced at 74 km. However, at 76 km, the density enhancement was not so significant. At the altitudes higher than 76 km, no electron density enhancement was appreciated. Thus the winter anomaly observed might be caused by atmospheric changes in the lower D-region.

The study also presents mesospheric wind measured with MF radars at Wakkanai and Yamagawa (31.2N,130.6E) during the anomaly period.

S16-P06

CHARACTERISTIC OF ATMOSPHERIC GRAVITY WAVES OBSERVED DURING THE WAVE2000 CAMPAIGN IN JAPAN

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On January 2000, the WAVE2000 (Waves in Airglow Structures Experiment over Kagoshima in 2000) campaign was carried out in Kagoshima. The purpuse of this experiment is to understand the mechanism of small-scale gravity wave structures in airglow image and to compare the altitude of the airglow emission layer estimated by ground-based triangulation with the altitude obtained from in-situ measurement by rocket. The ground observations by all-sky imagers were carried out in these site; Kagoshima Space Center (31.25°N, 131.08°E), Yamagawa Radio Observatory (31.20°N, 130.62°E), and Osumi Athletic Field (31.59°N, 131.00°E). We obtained image data of OH Meinel band, O_2 atmospheric band, and OI 557.7 nm on 6 nights during this campaign. We will report the results of height determination of airglow layer. And we have also calculated wave parameters (horizontal wave length, phase speed and propagation direction) using the 2-dimentional FFT method. Based on these parameters, we will discuss the general characteristics of gravity waves observed during this campaign.

S16-P07

THE INTERPLANETARY DISTURBANCES AND THE IONOSPHERIC BEHAVIOR OVER NORTH CHINA ON APR. 6, 2000

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The magnetic storm occurred at 16:42 UT on Apr. 6, 2000 causes an intense ionospheric storm over China region. The high solar wind observed about half an hour ago by ACE is responsible for this storm which is the strongest one occurs in this solar circle. The minimum *Dst* is about 318 (nT). The measurements of magnetic field show several sub-storms during the recovery phase of storm. The ionospheric storm begins at about 0200 BT (BT = 8 hr + UT), Apr. 7, there isn't marked positive phase following the start of the storm, and before 0700 BT the ionospheric storm behaves the negative storm comparing to previous day over the calculating region. From the contour line of TEC changes relative to previous day, it seems that TEC depletion in midnight side is intense than in the morning sector's. A positive phase occurs in the lower latitude region after about 0700 BT. From then on, the strength of the positive phase becomes stronger. At the same time, an intense negative phase occurs in the higher latitude region, the TEC depletion become stronger with time and it seems that the depletion region moves southwards gradually. The behavior of the ionospheric storm is consistent with the characters of ionospheric storm occurred in summer and at equinox that some authors summarized before. The wind transmitted from higher latitude is responsible for the negative phase in the mid-latitude region observed during this large magnetic storm.

S16-P08

MODELING STUDIES ON DAY-TO-NIGHT TEMPERATURE VARIATIONS IN THE THERMOSPHERE

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The thermospheric temperature is largely changed by the energy inputs from the Sun. The solar extreme ultra violet radiation and the energy of solar wind heat the thermosphere and the atmosphere releases the heat through the processes of infrared radiation and heat conduction to the space and the lower atmospheric region. These heating and cooling processes are variable and cause the thermospheric temperature variations with various time scales. In order to investigate the physics which determines such various time scales of the thermospheric temperature, we have developed numerical models of the thermosphere. Using the thermospheric models, we discuss about the day-to-night variations of the thermospheric temperature. The global mean temperature structure is governed by total energy inputs from the Sun and heat transfer processes, such as heat conduction and infrared radiation. In addition to these heating/cooling, dynamical effects on the day-to-night temperature difference will be estimated assuming some cases of energy inputs from the Sun.

S16-P09

OBSERVATION OF AURORAL SPECTRUM WITH A NEW AURORA SPECTROGRAPH

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Spectrum of auroral emission is now believed to be well understood. It is well established what atmospheric species produces what kind of emission in response to precipitating particles with a variety of energy spectrum. However, in order to fully understand the nature of optical aurora, we still need to obtain knowledge about how the auroral spectrum changes both in spatially and temporally with respect to the change in energy spectrum of precipitating particles. For instance, it is still remain unknown whether the spectrum of pulsating aurora does change or not corresponding to its on and off. To this end, a new aurora spectrograph has been developed at NIPR.

The aurora spectrograph is characterized by its high luminosity. The spectrograph consists of a large fish-eye lens (180-degree FOV, f = 6 mm, F1.4), a slit which passes the light from the sky along meridian direction, a collimating optics, a grism with 600 gr/mm, an imaging optics, and a digital camera with a back-illuminated CCD chip of 512×512 pixels. Actual performance of the spectrograph (wavelength range of 420 – 735 nm, spectral resolution of of 1.5 nm and sensitivity of 0.061 cts/pixel/Rayleigh/sec at 558 nm) was obtained through calibration performed using NIPR optical calibration facility.

The spectrograph was deployed at Aurora Station in Longyearbyen, Spitsbergen in early March 2000 and the full season observation will be started in the fall of this year. However, some interesting aurora spectra have been obtained in the test observation period.

S16-P10

MAGNETOSPHERIC DISTURBANCE EFFECTS ON EQUATORIAL THERMOSPHERIC WINDS AND SPREAD F

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Magnetospheric disturbances are known to modify the equatorial thermospheric dynamics and chemistry. The disturbance winds and electric fields in turn could modify equatorial spread F/plasma bubble irregularity development conditions in ways to enhance or inhibit its occurrences. Digital ionosonde/digisonde and optical data from Brazilian equatorial/low latitudes are analyzed during some recent magnetospheric disturbances to examine the control of disturbance electric fields and winds (especially the disturbance meridional winds) on the generation and/or inhibition of the spread F. The SUPIM (Sheffield University Plasmasphere-Ionosphere Model) has been used (based on a new methodology, *Souza et al.*, *JGR*, in press, 2000) to model the maridional wind and equatorial zonal electric field for quiet conditions to be used as reference for determining the disturbance components of these parameters and to identify their possible effects on the spread F developments. Preliminary analysis of some storm event that occurred in 1998 already show disturbance associated post sunset spread F development and associated perturbations (in zonal and meridional) winds as observed over Cachorira Paulista, Fortalez and Sao Luiz. The paper will present results based on analysis for a few quiet days and storm conditions.

S16-P11

INVESTIGATIONS INTO [OI] 558 NM NIGHTGLOW EMISSIONS DURING 1991 – 1993 AND 1997 – 2000 IN EAST SIBERIA

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In recent years there have been numerous attempts to analyze the various series of long-period observations in order to identify trends of atmospheric and ionospheric parameters and their characteristics. This is especially true in regard to observational series on upper-atmospheric emissions. This paper presents the observational data on atomic oxygen 558 nm emissions obtained in East Siberia (52N, 103E) during 1991 – 1993 and 1997 – 2000. An analysis is made of the behaviour of the seasonal variation of this emission for the concerned observing intervals. Observation results are compared with observational data obtained by other authors in different regions of the northern hemisphere during 1957 – 1970, and through a model approximation of the seasonal variation in 558 nm emission. With a qualitative agreement of the seasonal variations of the observations obtained during 1957 – 1970 and by a model approximation of the seasonal variation in 558 nm emission, the seasonal variation in the data presented shows a more pronounced autumn maximum in October. We discuss the possible influence of stratospheric warmings on the seasonal variation in 558 nm emission in the East Siberian region, characterized by a high recurrence of the stratospheric warmings centres in the winter months.

S16-P12

NUMERICAL MODELING OF THE LONGITUDINAL VARIATIONS IN THE THERMOSPHERE-IONOSPHERE-PLASMASPHERE SYSTEM

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The results of numerical modeling of the longitudinal variations of the upper atmosphere parameters have been presented. We have obtained them using the global upper atmosphere model for the 12 and 24 MLT of the March equinox of 1974 (low solar activity). The results have been plotted and analyzed in the geomagnetic coordinate system and compared with the data of the empirical International Reference Ionospheric model IRI-95. A good agreement between the theoretical and empirical data have been obtained for the F2-peak heights. We have tried to find the relations between the longitudinal variations of the electron concentration in the geomagnetically conjugate F2-layers, at the base of the protonosphere and at the tops of the geomagnetic field lines. These relations are very complicated and differ for the midday and midnight conditions due to the different responses of the ionosphere and plasmasphere to the longitudinal variations of the thermospheric winds and neutral gas composition. All of them are caused mainly by the offset between the geomagnetic and geographic axes.

S16-P13

A NEW COUPLED IONOSPHERE-THERMOSPHERE MODEL – A TOOL OF SPACE WEATHER FORECASTING

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A new coupled global Ionosphere-Thermosphere model is presented, with the main focus of addressing the challenge of predicting the Ionosphere-Thermosphere system, from the theoretical perspective. The model has been designed with emphasis on finer resolutions in both time and space, in order to target smaller-scale phenomena. The phenomena of interest are the low latitude ionospheric irregularities, and their interaction with the electrodynamics, AGWs and TIDs. The difficulty in understanding the cause and effect relationships are a consequence of the complex interaction processes between plasma and neutral species, and to high variability in both time and space. It is with the aid of such coupled models that the physics of these phenomena can be addressed, and systematically understood, to enable predictions to be made. The time-dependent model of self-consistent coupling between the ionosphere and thermosphere consists of three codes derived from independent origins. The first is a high- and mid-latitude ionospheric convection model, developed by *Quegan et al.* [1982]. The second is a global thermospheric model originally presented by *Fuller-Rowell and Rees* [1980; 1983], and which later evolved to the Coupled-Thermosphere-Ionosphere Model (CTIM) by incorporating the ionospheric convection model. Note that CTIM was limited to using an empirical model of the low-latitude ionosphere [*Chiu*, 1975]. The third component that has now been added is the low-latitude ionosphere/plasmasphere code developed originally by *Watanabe* [1995]. These three components now provide complete and global coverage of the thermosphere, ionosphere and plasmasphere. Our coupled ionosphere-thermosphere model is presented with the goal of understanding the physical processes at low-latitudes, including I-T coupling, and to demonsrate its value for space weather forecasting.

S16-P14

LONG TERM OBSERVATION OF NEUTRAL WIND VELOCITY AND TEMPERATURE IN THE MID-LATITUDE THERMOSPHERE USING AN IMAGING FABRY-PEROT INTERFEROMETER

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We are developing ground-based optical instruments to study physical process of gravity waves in the mesosphere and the thermosphere. The instruments (Optical Mesosphere Thermosphere Imagers: OMTI) have been set at the Shigaraki MU observatory (34.9 N, 136.1 E). The imaging Fabry-Perot interferometer (FPI), one of the OMTI system, observes the airglow emissions of atmospheric oxygen (OI) 630.0 nm (altitude: 200 – 300 km), OI 557.7 nm (96 km) and OH 839.9 nm (86 km) for measuring line-of-sight neutral-wind velocities and neutral temperatures. The FPI has been operated automatically since June 1999 at the Shigaraki observatory. In this presentation we analyze 630-nm datasets for a period from June 1999 to summer of 2000, and discuss seasonal variation of the wind and temperature in the mid-latitude thermosphere.

S16-P15

MIDLATITUDE IONOSPHERIC DISTURBANCES DURING GEOMAGNETIC STORMS

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Simultaneous variations of ionospheric critical frequency foF_2 and the H-component of the geomagnetic field at middle latitudes are compared with solar wind data during several magnetic storms for STEP period. Dependence of foF_2 variations from latitude and from B_z-component of the IMF is found. Based on these facts we made attempt to understand the causes foF_2 variations at midlatitudes. For this purpose we extended our equatorial model of the field-aligned currents on midlatitudes. It is shown that the field-aligned currents from Region 1 and 2 during magnetic storms can penetrate to equator across midlatitude ionosphere and modify foF_2 variatins there.

S16-P16

INTERHEMISPHERE COMPARISON OF SPORADIC E OCCURRENCES OBSERVED BY IONOSONDE NETWORK

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Sporadic E, or Es cause a severe interference in the TV and communication channels of VHF band. Es is variable and an occurrence peak appears in summer in Asia. Es is particularly important in Asia because of increasing radio users of VHF band and expanding mobile radio communication users. We made a comparison of hourly value $foEs$ and $h'Es$ observed at observatories of Japan, China and Australia. This shows seasonal dependence of Es occurrence in the northern hemisphere and southern hemisphere. In the latitudinal dependence of Es occurrence in February, 1997 it seems to appear wavelike structures having a long scale wavelength more than 2000 km. The statistics of Es occurrence will be presented by using a long term ionosonde data base in Japan. In Japan there is an intensification of the summer maximum for $fEs > 15$ MHz. This phenomena appear unique to the Far East. While the windshear theory is widely accepted, it does not explain the Es temporal distributions. We speculate a role of planetary scale wave on the cause of summer maximum in temperate-latitude sporadic E by interhemisphere comparison.

S16-P17

MAPPING OF TOTAL ELECTRON CONTENT OVER JAPAN USING GLOBAL POSITIONING SYSTEM OBSERVATIONS

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Total electron content (TEC) along the GPS ray path is derived from pseudoranges and phase delays of the dual frequency GPS signals. The main source of error in the derivation of vertical TEC is from satellite and receiver instrumental biases, which reach up to several tens of TEC units. In order to obtain absolute vertical TEC, these instrumental biases are to be taken care of. We have developed a new technique to derive two dimensional map of absolute TEC over Japan by using the GPS earth observation network (GEONET) in Japan, which consists of more than 1,000 GPS receivers. In order to validate this technique, the estimated values of TEC are compared with the MU radar TEC values obtained by integrating the electron density profiles from 100 km to 1,000 km altitude under low solar activity. The estimated TEC from GPS shows similar diurnal and day-to-day variations as the MU radar TEC although its magnitude exceeds the MU radar TEC by 2 TEC units, which are expected to be plasmaspheric contribution. This technique has also been applied to GPS data during the magnetic storm of September 25, 1998. An intense TEC enhancement with duration of 6 hours has been observed at the evening at the southern part of Japan and similar, though small, enhancement is observed in GPS TEC and MU radar TEC at the MU radar location. Electron density profiles and plasma drift velocities observed with the MU radar for this event are also shown.

S16-P18

WAVE DISTURBATIONS NEAR TERMINATOR IN DEPENDING ON A PHASE OF A CYCLE OF SOLAR ACTIVITY

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1. On a database multi channel inclined doppler of HF-sounding received for the period, which covers two 11-year's cycles of solar activity (1978 – 1990 years), the phenomenon of short-term restoration of communication in evening time on one jump middle latitude radio lines after passage of border of a dead zone (BDZ) through reception item is analyzed. The variations of amplitude and frequencies accompanying this effect are similar focus of a HF-signal on BDZ at first morning, and then evening type. In some cases the given effect can repeat up to three times.
2. The analysis of the reasons of restoration and loss of connection has allowed to make the following conclusion: the border of a dead zone on call of the Sun at first passes through reception item (regular daily course) and leaves from it, then comes back to reception item and again leaves from it. The given effect was named "returnable focus". The reason of such behaviour BDZ is connected with wave disturbances, resulting to quasi-periodic to variations of electronic concentration in area F. It proves to be true by the data of vertical sounding ionosphere, received near to the centers of used radio lines and in a point of reception. During supervision of the phenomenon "returnable focus" in a daily course foF_2 the short-term increase of critical frequency reaching 20 % is observed. Thus, the phenomenon "returnable focus" is the indicator wave disturbances of the top atmosphere, which source is solar terminator.
3. The researches of parameters "returnable focus" depending on a level of solar activity have shown, that them demonstration is maximal in a minimum of solar activity ~ 47 and falls at transition to a maximum of solar activity up to $\sim 8 - 10$. The period wave disturbances grows with increase of solar activity from ~ 13 minutes during a minimum of solar activity up to ~ 50 minutes during a maximum.

S16-P19

A NEW TYPE OF FIELD-ALIGNED IRREGULARITIES IN MID-LATITUDE E-REGION IONOSPHERE

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Quasi-periodic (QP) and continuous structures are the typical and universal features of several-meter scale field-aligned irregularities (FAIs) at low and mid-latitude ionosphere.

The QP echoes appear primarily between sunset and midnight, are localized in slant range, from a kilometer to more than 50 km in extent and often appear as thin sloping striations in range-time-intensity displays. They tend to be discrete and recur with QP patterns at intervals of approximately 2 – 15 minutes. On the other hand, continuous echoes appear primarily in early morning hours as a thin continuous layer below 95 km.

Recently, the MU radar at Shigaraki (34.85 N, 136.10 E) has revealed a new type of structure or kilometer-scale waves with vertical wavelengths of 0.6 – 1.2 km and periods of 30 – 60 s over a narrow height range of 92 – 97 km. They show negative and positive range rates as the QP echoes but change systematically from one to the other.

This finding seems supportive to a hypothesis which suggests that FAIs are closely related to localized density gradients in sporadic-E layers, and should be taken into considerations in designing a rocket/radar/optics campaign called SEEK-2 (Sporadic-E Experiment over Kyushu-2) which is planned to be conducted in Kyushu Japan in summer 2002.

S16-P20

SPATIAL DISTRIBUTION OF IRREGULARITY OCCURRENCE RATE IN THE SUBAURORAL F REGION AS OBSERVED BY THE SUPERDARN RADARS

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The HF radars of the Super Dual Auroral Radar Network (SuperDARN) observe the convective drift of ionospheric plasma when suitable deca-meter scale irregularities are present. In order to estimate the distribution of the irregularity appearance in subauroral region, we have investigated the scattering occurrence rate using the data of northern hemisphere radars during 39 months between July 1995 and September 1998. The most significant result is that the distribution of scattering occurrence rate, which is approximately identical to the irregularity occurrence rate, has a clear peak in the duskside subauroral region around the terminator throughout the year. On the contrary, a weak enhancement appears around the dawn terminator only in the winter and no detectable peak is found in the other seasons. These peak regions around the terminator closely correspond to the area of higher longitudinal density gradient. This irregularity enhanced region is located in dusk sector subauroral region whose invariant latitude is slightly lower than the equatorward edge of the auroral oval in geomagnetic coordinate system. The area coincides with the plasma density depleted region known as the mid-latitude trough. Main feature of the scattering occurrence peak region in our statistical analysis is quite similar to the characteristics of the dusk scatter event reported in *Ruohoniemi et al.* [1988], which indicates that enhanced scattering occurrence around the dusk terminator is mainly composed by the dusk scatter event. The dependence of the peak region on the level of geomagnetic disturbance as estimated by Kp index was also examined. In the seasons except for winter, scattering occurrence rate does not peak around the dusk terminator.

S16-P21

MODELING THE HIGH-LATITUDE IONOSPHERE

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We present a nonstationary, three-dimensional model of the ionospheric F-region above 150 km that is applicable at middle, auroral and polar latitudes. The model makes it possible to calculate the height density distributions of the H^+, O^+, NO^+, $N2^+$ and O_2^+ ions, of electron and ion temperatures, as well as of charged particle and heat fluxes through a numerical integration of MHD transport equations of thermal plasma inside dipole plasma tubes drifting under the action of the magnetospheric convection electric field. Thermospheric parameters are described in terms of empirical model MSIS-86, and the solar EUV-radiation fluxes are taken in acordance with the EUVAC spectrum. The model uses an approximate method of calculating neutral wind velocities. Characteristics of magnetospheric effects can be specified by two methods: from appropriate empirical models, or by using methods of reconstructing them from magnetograms (MIT, AMIE). To evaluate the accuracy of the model, we present results of test calculations of two kinds. In the first place, we have modeled typical diurnal vartiations of ionospheric parameters at latitudes above 40 degrees of the northern hemisphere for a low ($Kp = 1$) and high ($Kp = 5$) levels of geomagnetic activity. All input data are specified from the respective empirical models. It is shown that the model reproduces quite well all of the known large-scale structures of the ionospheric F-region at middle auroral and polar latitudes. A comparison with foF_2 measurements for 14 ionospheric stations located northward of 55 degrees for the summer and winter conditions at low and high activity made it possible to determine the relative error of calculations to lie within $10 - 60$ %. Secondly, the model was applicable for a description of the diurnal variations of NmF_2 during the geomagnetic storm of March 22, 1979. The behavior of magnetospheric parameters at the time of the storm was specified both from empirical models and by the MIT method. On the basis of the ionospheric model presented, it was possible to solve the problem of the formation of the polar hole (PH). It is found that the PH is produced in the nightside zone of the polar cap where the vertical projection of the convection velocity is directed downward, while

the local ion production rate is small.

S16-P22

STUDIES OF GPS-TEC USING GEONET, MU RADAR AND SUPIM

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The absolute values of the total electron content (TEC) in the GPS ray paths over Japan are derived from the carrier phase delays and pseudoranges of the GPS signals (1.57542 GHz and 1.22760 GHz) recorded by the GPS receiver network (GEONET) in Japan; the instrumental biases inherent in the receivers and transmitters are taken care of by using a least square fitting method. The values of GPS-TEC derived for high solar activity are compared with those calculated by the Sheffield University plasmasphere ionosphere model (SUPIM). The derived values of GPS-TEC are also compared with the ionospheric electron content (IEC) up to 1000 km altitude measured by the MU radar and calculated by SUPIM. These comparisons validate the method used for the derivation of GPS-TEC. The electron content in the plasmaspheric sections of the GPS ray paths are also estimated. According to the estimates, the plasmaspheric sections of the vertical GPS ray paths over Japan at altitudes above 1000 km contain up to 12 TEC units of free electrons, which can cause propagation errors of up to 10 ns in time delay and 3 m in range in the GPS L1 band frequency. The plasmaspheric electron content (PEC) changes appreciably with season and latitude and very little with the time of the day. However, the percentage contribution of PEC to GPS-TEC varies from a minimum of about 12 percent during daytime at equinox to a maximum of about 60 percent at night in winter.

S16-P23

MID-LATITUDE IONOSPHERIC DISTURBANCES DURING THE FEBRUARY 11 – 12, 2000 GEOMAGNETIC STORM

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Regular all-sky imaging observations of the F-region OI 630 nm nightglow emission are carried out from Rikubetsu (43.5 N, 143.8 E; geomag. 34.9 N) and Shigaraki (34.8 N, 136.1 E; geomag. 26.6 N), Japan since 1998. In this communication, we present observations of the OI 630 nm emission from these two sites with a cluster of other observations during the geomagnetic storm of February 11 – 12, 2000 (SSC at 0258 UT on February 11 and main phase at 1200 UT with provisional $|Dst|_{max}$ of 169 nT on February 12). The airglow observations from both the sites on February 12 between 1500 UT to 2000 UT, show presence of large-scale enhanced airglow bands moving to the south-west direction. Shigaraki observations also show presence of small-scale intensity depletion structures in the southern part, where the emission levels are high. Simultaneous ionosonde observations from Wakkanai (45.4 N, 141.7 E; geomag. 35.2 N), Kokubunji (35.7 N, 139.5 E; geomag. 25.5 N) and Okinawa (26.3 N, 127.8 E; geomag. 15.3 N) and GPS phase fluctuations and TEC data have also been analyzed. The ionosonde observations from Wakkanai and Kokubunji show presence of bottom-side F-region irregularities, where as the ionosonde observations from Okinawa do not show any such irregularities. Similar results related to the F-region irregularities are also obtained from the GPS phase fluctuations indicating that the F-region irregularities generated were limited to mid-latitude region and are possibly associated with traveling ionospheric disturbances launched during the magnetic disturbance.

S16-P24

ON RELATION OF EQUATORIAL IONOSPHERIC SCINTILLATION PHENOMENA AND GEOMAGNETIC FIELD (MAINLY DURING PREASA-5 CAMPAIGN PERIOD)

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Equatorial ionospheric scintillation has been studied for a long time and various characteristics of it have been clarified. *Basu et al.* (1985) reviewed that seasonal characteristic of occurrence of scintillation depends on longitudes, but there was no data at about 100 deg. E longitudes among the data discussed by them. Then in order to investigate ionospheric scintillation near the magnetic equator over a 100 deg. E longitude sector, scintillation observing systems have been installed at Bangkok (13.7 deg. N, 100.8 deg. E; 2.8 deg. N geomag.) and Chiang Mai (18.8 deg. N, 99.0 deg. E; 7.9 deg. N geomag.), Thailand early in 2000 under POST-PARTNERS project by CRL. Temporal variations and spatial distributions of ionospheric irregularities are observed by measuring amplitude scintillation of satellite radio waves from GMS (geostationary) and GPS (orbiting) at two stations. Early observation results have already been reported by *Minakoshi et al.* at 2000 WPGM in June, 2000. They showed that scintillations simultaneously occur at both stations during pre-midnight when the background TEC (Total Electron Contents) frequently increase or fluctuate and scintillation activity seems to be higher at Chiang Mai than Bangkok. These features so far coincide well with usual equatorial irregularities observed over other longitude sectors and are thought to be concerned with fountain effect. If so, it is thought that there were ionospheric currents originated from ionospheric electric fields which generate fountain effect and the currents affect geomagnetic fields. In this presentation we will report results analyzed about the relation of ionospheric scintillation phenomena and geomagnetic field using mainly the data during PREASA-5 campaign period from February 22 to March 14, 2000.

S16-P25

APPROACHES TO STUDY THE IONOSPHERIC ANOMALIES WITH GPS AT A SINGLE STATION

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In this paper, several approaches of using GPS data are presented to study the ionospheric anomalies at a single station, which were traditionally studied by foF_2. The diurnal variation of ionospheric TEC through only the measured data of time-delay (pseudo-range) of GPS signals without using any phase information is suggested and this makes the procedure to study TEC day-to-day variations is greatly simplified. On the other hand, a method of combining differential pseudo-ranges and phases is used to analyze the manifestation of flares, acoustic-gravity waves in the ionosphere. A simple method to minimize the effects of satellite clock bias and the receiver clock error is also suggested and it is shown that these methods are valid for special purposes of different ionospheric anomaly studies. The calculated parameter is the vertical TEC, which is the average of vertical projections of all the line-of-sight TEC from different satellites in a conical angle of 60 degrees around the local vertical direction. Using this parameter, TEC day-to-day, seasonal and annual variations are analyzed and compared with the classic anomalies revealed by critical frequencies. Examples of effects of flares and gravity waves on TEC are presented, too. Finally, it is pointed out that during nighttime, ionospheric irregularities may contribute to a certain degree to the multi-path effect.

S16-P26

IONOSPHERIC HEIGHT CHANGES NEAR THE MAGNETIC EQUATOR AND VORTEX-LIKE $\boldsymbol{E} \times \boldsymbol{B}$ DRIFT

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Changes in the ionospheric height during post-sunset hours are compared for two stations near the magnetic equator: Cebu Island (124 deg. E, 10.3 deg. N; 2.2 deg. N in diplatitude) and Manila (121 deg. E, 14.6 deg. N; 7.1 deg. N in diplatitude), both in the Philippines. Ionograms were obtained every five minutes during the WestPac98 (Western Pacific) ionospheric campaign conducted in March 1998. The ionospheric height changes during evening hours at the two stations showed various features from day to day. We summarized cases into three types: (a) the heights at two stations varied almost identically; (b) they varied similarly but the height at Cebu was always $20-30$ km higher than at Manila; and (c) they varied in a fairly complicated way. Equatorial spread F during evening hours was observed on two type-c days. The height changes on those days are analyzed in detail. The prereversal enhancement in upward $\boldsymbol{E} \times \boldsymbol{B}$ drift started simultaneously at both stations, but drift direction reversed one hour earlier at Cebu than at Manila. The zonal electric field over Manila is mapped onto the magnetic equator along the magnetic field line. The corresponding height at the equator is 88 km higher than over Manila. Thus, the difference in drift direction between the two stations is presumed to be the difference at the two corresponding heights over the magnetic equator. One possible explanation for this complexity is the manifestation of a vortex-like convection of $\boldsymbol{E} \times \boldsymbol{B}$ drift. Although we only have observations for two days during the campaign, the spread F occurrence and the peculiar height changes seem to be related to each other.

S16-P27

RADIO TRANSLUENCE METHOD AND MONITORING THE EARTH IONOSPHERE

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The using GPS for study and condition control of the Earth ionosphere represents the scientific – technological break in the field of remote sounding of the upper atmosphere and has a global perspective.

Nowadays monitoring of the ionosphere passes on a new methodical and technological level stipulated by full deployment of the GPS and Glonasssystems and development of algorithms of the transformation of parameters of dual frequency radio signals in parameters of the ionosphere – the integral electron contents and high-altitude profiles of electron concentration. This transition is new era in ionospheric researches, as main properties of the GPS system – capability to conduct measurements continuously in time in any point of globe – immediately are transferred on ionospheric monitoring and allow to supply research of global and regional appearances in the ionosphere.

The methodology of researches, based on the solution of ill posed problems, is one from new directions in study of processes happening in the Earth ionosphere. The interest to the solution of problems, arising at it, is called by needs of practice in connection with broad propagation and necessity of the registration of dynamic effects and non-uniformity of atmospheric processes. These effects essentially limit application of classical methods and the creations of the new approaches require.

The presence of a network of ground items IGS and reference regional items CORS allows to receive the data of measurements in various points of the Earth surface. These data are good additional, and frequently and unique information on dynamics of the ionosphere at such heliophysical and geophysical processes in the given region, as a solar eclipse and earthquakes.

The realization of a radio translucence method because of these measurements allows to conduct researches of a maximum variations of electron concentration with detection of a various kind of regularities.

S16-P28

ZONAL DRIFTS OF IONOSPHERIC PLASMA DEPLETIONS OVER BRAZIL FROM 1980 TO 1994

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The zonal drifts of the ionospheric plasma bubbles over Brazil are studied here based on velocity magnitudes inferred from scanning airglow (OI 630 nm) data, from 172 nights of experiments carried out from Cachoeira Paulista (22°48'S, 45°00'W, dip 30°S) from 1980 to 1994. The velocity magnitudes are studied here as a function of solar cycle activity, geomagnetic activity (Kp index), season, local time and solar flux.

S16-P29

SPACE-TIME PECULIARITIES ANNUAL VARIATION OF GEOMAGNETIC FIELD LEVEL AND ITS POSSIBILE SOURCE

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Space-time peculiarities of season changes of H, Z-components and declination D have been studied using data 1964 year of 36 magnetic observatories situated in northern hemisphere successive across $1-5°$ in range latitude $4-82°$N. In result an annual variation of geomagnetic field level has been revealed. Its amplitude changes gradually approximately following parabolic curve from minimum winter values to maximum summer values. Annual variation does not depend on longitude, but has clear dependence upon latitude, annual variation amplitude is maximum at high latitudes and gradually decreases value towards equator. Note, that annual variation amplitude depends from solar activity. In year of high solar activity (data 1968 year) in 1.5 time more than amplitude observed in year of low solar activity.

Spherical harmonic analysis and equivalent current system constructed on its base have shown space-time peculiarities of annual variation of geomagnetic field level to be having clear regularity, that can be described by particular current system. Current lines directed eastward form loop around pole, expanding whole summer hemisphere. Therefore, similar current system was called as circumpolar one. Maximum current intensity is in polar latitude and gradually decreases to zero on the equator.

It is obvious, that electric fields of circumpolar ionospheric current system must influence both on the ionosphere-magnetosphere and ionosphere-thermosphere coupling. Author proposed, that obtained result supplements our notion about Sun-Earth connection.

S16-P30

VHF $1/F^{\alpha}$ NOISE OF MIDLATITUDE IONOSPHERE DURING SOLAR ECLIPSE AND MORNING TERMINATOR PASSING

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Radionoise fluctuation measurements of ionosphere plasma in frequency range $0.0004-50$ Hz were conducted at wavelength $l = 2$ m. During measurements geomagnetic activity was quite low and solar activity was middle ($\Sigma \sim 12$, $F10.7 \sim 130$). Also, solar flares were absent.

It was found that radionoise fluctuation spectrum of ionosphere plasma in quiet conditions may be described by the dependency $S(f) \sim 1/f^{\alpha}$, where $\alpha = 0.30 + 0.02$ in day and night time. Disturbance cause grow of a. Namely, passing of acoustic wave from full phase zone of solar eclipse on Aug 11, 1999 caused a increasing up to 0.53 and passing of morning terminator on Aug 12, 1999 at altitude ~ 100 km up to 0.63. In both cases fluctuation grow took place in frequency range $0.01-1.0$ Hz. The difference is that during eclipse spectrum has discrete structure but during morning terminator passing it was continuous.

S17-01

THE TROPICAL COLD POINT TROPOPAUSE: QBO AND ENSO INFLUENCES

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The influences of the Quasi-Biennial Oscillation (QBO) and the El Nino Southern Oscillation (ENSO) on the tropical cold point tropopause (CPT) have been separated using bivariate regression. The stratospheric zonal wind shear at 50 mb lags/leads the variation in the tropical CPT temperatures by about 6/10 months. The QBO influence on the tropical CPT is mainly zonally symmetric and is readily explained as being due to the QBO-induced meridional circulation. CPT temperatures and the sea surface temperature anomalies (SSTA) in the Nino3.4 region are simultaneously correlated and the fingerprints of the SSTA in the CPT show a dipole feature. The simultaneous anti-correlations between CPT temperatures and SSTA in the Nino3.4 region are explained by changes in convection during ENSO events. Some modeling results are shown indicating low frequency variations in the entry value of water vapor across the tropical CPT into the stratosphere.

S17-02

A NUMERICAL EXPERIMENT ON INTRASEASONAL AND INTERANNUAL VARIATIONS OF THE TROPOSPHERE-STRATOSPHERE COUPLED SYSTEM

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A numerical experiment on the dynamical coupling between the troposphere and the stratosphere is done with a global circulation model (T21 truncation and 42 levels) with some idealizations; it is a dry-atmosphere model with a Newtonian-type radiation scheme for meridional differential heating. An idealized surface topography of zonal wavenumber one is introduced to make zonal asymmetry and its height is changed from 0 to 3 km for 10 runs as an experimental parameter. Nonlinear interactions among zonal mean zonal flow, planetary waves forced by the topography, and baroclinic disturbances produce irregular fluctuations in the troposphere and also in the stratosphere with multiple time-scales from intraseasonal to interannual variations. For each run, time integrations are done for 100 years with a periodic annual forcing of the meridional differential heating.

Even in the run with no surface topography, the model response shows (small) interannual variations in the polar stratosphere. If the topographic height is small (around 500 m), the polar stratosphere shows large variability in spring. On the other hand, the variability is large in winter for medium topographic heights (around 1000 m). These results remind us of the variations in the southern hemisphere and the northern hemisphere, respectively.

The dynamical coupling is inevitably two-way. Large stratospheric events are mainly caused by vertically propagating planetary waves from the troposphere, while circulation changes in the stratosphere influence upper and middle troposphere for a time scale of a month. Such coupling is significant in the season when the interannual variations are large, depending on the topographic height. The dynamical vertical link is also analyzed from the viewpoint of Arctic Oscillation, which was found recently as a deep signature of modulations in the strength of the polar vortex from the mid-stratosphere down to the surface on the intraseasonal and interannual time scales.

S17-03

ATMOSPHERIC PROCESSES IN THE TROPICAL TROPOPAUSE REGION REVEALED FROM 1998 – 2000 SOWER/PACIFIC CAMPAIGNS

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Soundings of Ozone and Water in the Equatorial Region/Pacific Mission (SOWER/Pacific) is initiated to improve our understanding on the distribution and variations of the ozone and water vapor in the stratosphere and troposphere of the equatorial Pacific. The mechanism of mass exchange across the tropical tropopause is one of the main topics in the scope of SOWER/Pacific. In the present paper, the meteorological properties of the tropical tropopause region together with the wave activities in the troposphere are discussed based on the analysis of the operational radiosonde data taken at Singapore (1.37 N, 103.98 E) and San Cristobal (0.90 S, 89.62 W). Analyses are extended by using the ozone and water vapor sonde data at San Cristobal and Christmas Island (2.01 N, 157.40 W) obtained from 1998 – 2000 SOWER/Pacific campaigns. Special attention will be paid to the role of the atmospheric waves on the exchange of minor constituents between the troposphere and the stratosphere based on the idea of *Tsuda et al.* (1994) and *Fujiwara et al.* (1998). Although the observations are still limited both in space and time, evidences will be shown suggesting the important role of Kelvin waves on controlling the water vapor budget in the tropical stratosphere and thus maintaining the dryness of the tropical tropopause region.

S17-04

POLAR STRATOSPHERIC CLOUDS (PSCs) OBSERVED FROM SPACE

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Space-borne sensors have the advantage of being able to monitor the frequency of Polar Stratospheric Clouds on a large spatial coverage. Many satellite sensors such as SAMII, SAGEII and POAMII have observed PSCs. *Hayashida et al.* [2000] reported detailed analysis of Arctic PSC occurrence observed with the Improved Limb Atmospheric Spectrometer (ILAS) which was launched on board the Advanced Earth Observing Satellite (ADEOS) in August 1996, and continued regular operation until June 1997 [*Sasano et al.*, 1999]. ILAS is an occultation sensor and observed fourteen circumpolar points in each hemisphere every day at high latitudes (57.1°–72.7° N and 64.3°–88.2° S). The ILAS provided a very unique data set, including aerosol (780-nm extinction), nitric acid, water vapor, and nitrous oxide measurements, simultaneously. By combining the thermo-dynamical model to calculate the volume and compositions of particles and the observed mixing ratio of nitric acid in gas phase and aerosol volume, we can estimate chemical compositions of the particles. Some PSC data observed over the Arctic in 1997 with ILAS show good correspondence to the STS (supercooled ternary solution) particles at low temperatures. Other PSC studies using satellite sensors will be also reviewed and discussed.
Sasano, Y. et al. Improved Limb Atmospheric Spectrometer (ILAS) for stratospheric ozone layer measurements by solar occultation technique, *Geophys. Res. Lett.*, **26**, 197–200, 1999.
Hayashida et al., Arctic Polar Stratospheric Clouds Observed with the Improved Limb Atmospheric Spectrometer during the Winter of 1996/1997, *J. Geophys. Res.*, 2000 (in press).

S17-05

SIMULATION OF OZONE VARIATIONS IN CHEMICAL CLIMATE MODELS

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Solar radiation has the variation of 11-year sunspot cycle. The corresponding variation in the solar constant is small (0.1). But, the change in the ultraviolet radiation of the sun is much larger than that of visible radiation. Recently, it has begun to do quantitative analysis of the relationship between solar activity and a long-range climate change of stratospheric temperature and ozone. Satellite observations show that the ozone content increases by 2 from sunspot minimum to maximum, and the temperature difference in the stratosphere between minimum and maximum of the 11-year cycle reaches 1.8K. Numerical experiments using a CCSR/NIES AGCM with coupled chemistry for the middle atmosphere are performed. The AGCM has a horizontal resolution of T21. There are 33 layers from the surface to 70 km in the vertical. Integration is 20-year for each at solar maximum and minimum. Numerical results and the comparison with observations will be presented.

S17-06

MIDDLE ATMOSPHERE RESPONSE TO STATIONARY TROPOSPHERIC WAVES AT HIGH LATITUDES OF THE SOUTHERN HEMISPHERE: 3-D MODEL RUNS

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The numerical simulations of middle atmosphere response to tropospheric stationary large-scale disturbance were realised using 3-D general circulation model developed at the University of Cologne (COMMA) and installed at Central Aerological Observatory (Russia) for using. Spatial structure of (UKMO data) such disturbance used in model calculations as a low boundary condition was determinate on the basis of data analysis for high latitudes of the southern hemisphere. It was found that strong stationary waves with zonal wave number one ($M = 1$) appear regulary near Antarctica. These waves has its maximum of intensity approximately at 60 S with long-term amplitudal modulation which looks like QBO. It was found also that such waves has a great manifestation in total ozone. The amplitude of first zonal harmonic reaches sometimes a level of values more than 100 DU. Interannual analysis of these disturbances shown also their existance during several months with a maxima of the effect in September. These character features were used to formulate lower boundary conditions for 3-D model simulations. The results of data analysis for 1992 with tropospheric disturbance of high pronounced were used for model calculations. The results of simulations has revealed the penetration of tropospheric stationary wave into the mesosphere. Global structure of tropospheric response for wind and temperature fields which must be important for D-region has been calculated.

S17-07

GRAVITY WAVE CHARACTERISTICS IN THE ANTARCTIC REVEALED BY OPERATIONAL RADIOSONDE DATA AT SYOWA STATION

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Gravity waves in the polar region are examined based on high-resolution operational radiosonde data at Syowa station (69.0 S, 39.5 E). Monthly mean vertical wavenumber spectra of normalized temperature were calculated in the height region of 4 − 8 km (troposphere) and 17 − 24 km (lower stratosphere). The compensation considering the response time of a temperature sensor was applied to the observed vertical wavenumber spectrum following *Allen and Vincent* [1995]. In the troposphere, the observed spectra show little seasonal variation. The slope of the spectrum in the wavenumber range of 0.4 − 3.3 cycle/km is always about −2.7 in the troposphere. To the contrary, there are strong seasonal variations in the stratosphere. In November, when the gravity wave energy enhancement is observed in the lower stratosphere, the observed spectrum is roughly the same as the model spectrum of saturated gravity waves proposed by *Smith et al.* [1987], and the slope is about −2.8. In the other seasons the power spectrum density decreases mainly in the wavenumber region around 0.5 − 1 cycle/km (corresponding to the wavelength of 1 − 2 km) while it remains unchanged in the larger wavenumber region. Thus the slope of the spectrum reduces to about −2.3. These spectral characteristics are quite different from the observations in the low and middle latitude regions.

S17-08

AN INTERHEMISPHERIC COMPARISON OF GRAVITY WAVES IN THE POLAR MESOSPHERE

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Mesospheric winds observed with an MF radar at Davis Base, Antarctica, (68S, 77E) are compared with measurements made with a similar radar system at Poker Flat (65N, 147W) in Alaska. A key feature of the observations is the excellent height coverage at both sites, with winds measured down to altitudes near 50 km in winter and with 24-hr coverage down to at least 70 km in summer. Stokes parameter techniques are used to derive information on gravity-wave activity as a function of height and time in a number of period bands. Observations made in 1999 are used to compare hemispheric variability in wave amplitudes, while observations made from 1994 to 2000 at Davis provide information on interannual variability. The results are used to explore possible hemispheric differences in coupling from below and in gravity wave driving of the meridional circulation.

S17-09

CHARACTERISTICS OF WAVE STRUCTURES IN THE LOWER STRATOSPHERE OVER THAILAND

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The main target of this study is gravity waves in the lower stratosphere over the southeast Asian monsoon region. So far, characteristics of gravity waves in this region have not yet been studied, because there have been limited number of observations which have enough resolution to detect gravity waves. But in recent years, GAME (GEWEX Asia Monsoon Experiment) -Tropics project have carried out enhanced rawinsonde observations at Sukhothai (17N, 100E) and Nongkhai (18N, 103E) in Thailand, which are very high resolution observations in time and height (3 hr and 25 m, respectively). These high resolution data made us possible to analyze gravity wave parameters. In this study, we try to describe gravity-wave nature in the lower stratosphere over Thailand and to examine dynamical coupling between monsoon system and gravity waves. The preliminary results of our analyses are introduced below.

The enhanced rawinsonde observations have revealed clear wave structures in the lower stratosphere (above about 17 km altitude) in both rainy and dry seasons. Vertical wavenumber spectra calculated from the data in an altitude range of $19 - 27$ km have a spectral slope of approximately -3 in the higher vertical wavenumbers. The spectral power in the lower vertical wavenumbers are larger in rainy season than in dry season, which suggests that the wave disturbances in the lower stratosphere is originated by cumulus convection associated with Asian monsoon activity. Frequency spectra show two isolated peaks at 1 day and near the inertial period. The former is thought to be diurnal tide. The waves with the period near the inertial period have slower downward phase speed and shorter vertical wavelength than 1-day waves. Detailed structures of these wave are investigated and presented.

S17-10

A GLOBAL DISTRIBUTION OF ATMOSPHERIC GRAVITY WAVES IN THE STRATOSPHERE REVEALED BY THE GPS OCCULTATION DATA

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We have extracted mesoscale temperature perturbations with vertical wavelengths ranging from 2 to 10 km, using temperature profiles obtained in the stratosphere observed with the GPS/MET (GPS Meteorology) experiment from April 1995 to February 1997. We then evaluated a potential energy, E_p, which is assumed to be caused by atmospheric gravity waves. The largest E_p values are generally centered around the equator between 25 N and 25 S with considerable longitude variations. Longitudinal variations of E_p at $20 - 30$ km in a latitude range of $30 - 60$ N are also analyzed, resulting in larger E_p values over the continents than over the Pacific ocean. Latitudinal variations of E_p are determined in $15 - 45$ km. Although large E_p values are concentrated near the equator at $20 - 30$ km, E_p tends to become larger at midlatitudes at $30 - 40$ km and higher altitude regions. At midlatitudes, E_p is found to be larger in winter months in both hemispheres.

S17-11

NUMERICAL SIMULATION OF THE MESOPAUSE SEMIANNUAL OSCILLATION

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The mechanism of the mesopause semiannual oscillation (MSAO) is investigated by using a GCM developed at Kyushu University. The GCM is T21L55 model, and contains the region from the ground surface to about 145 km height. Results are as follows. In the equatorial mesopause region, the westerly acceleration is mainly caused by the ultra-fast Kelvin wave (zonal wave number 1 or 2, 3 – 5 day period). The easterly acceleration is mainly caused by the diurnal and semidiurnal tides. The amplitude of the EP flux divergence due to the diurnal and semidiurnal tides has semiannual variation. These results indicate that breaking of the tides and the ultra-fast Kelvin wave in the mesopause region is key factor of the MSAO.

S17-12

THE DROPPS PROGRAM: A STUDY OF THE POLAR SUMMER MESOSPHERE WITH ROCKET, RADAR AND LIDAR

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DROPPS (The Distribution and Role of Particles in the Polar Summer Mesosphere), a highly coordinated international study conducted in July 1999, involved two sequences of rockets launched from the Norwegian rocket range in Andøya, Norway. These studies were designed to investigate the properties of the polar summer mesosphere, particularly relating to polar mesospheric summer echoes (PMSE) and their possible relationship to particles (aerosol and dust layers) and to noctilucent clouds (NLC). Each of the two sequences included a DROPPS NASA-Black Brant payload, consisting of an array of instruments to measure the electrodynamic and optical structure of the mesosphere and lower thermosphere. These were provided by participants from several US and European scientific laboratories. The DROPPS payloads were each accompanied by a sequence of several European payloads designed to study electrodynamic structure of the same region, and by several meteorological rockets to provide wind and temperature data in the critical region of study. ALOMAR Lidars, and MF and MST Radars (all located adjacent to the Andøya launch site) were used to continuously monitor the mesosphere for NLCs and PMSEs, respectively. EISCAT VHF radar (Tromsø Norway) provided similar information about PMSEs, about 130 km downstream from Andøa. Sequence 1 was launched during the night of 5 – 6 July into a strong PMSE display with a weak NLC at the base of the PMSE layer. Sequence 2 was launched on the early morning of 14 July into a strong NLC, but surprisingly with no PMSE evident. Of note is the observed presence of negatively charged particles within the PMSE region but absent from the NLC. The PMSE layer also contained electrodynamic turbulence, which was absent within the NLC observed during Sequence 2. This overview discusses the program, including findings from the DROPPS rocket data and their preliminary implications.

S17-13

SOLAR DISTURBANCES AND THEIR GEOSPACE IMPACTS: SNOE, SAMPEX, AND POLAR OBSERVATIONS

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Coronal mass ejections (CMEs) are observed to have significant effects in near-Earth space. Fast CMEs in May, September, and October of 1998 had strong interplanetary shock waves ahead of large magnetic cloud structures. It is important from a sun-Earth connections standpoint to understand magnetospheric and atmospheric responses to CME/cloud events. The 1998 CME events were first observed by SOHO sensors and they subsequently produced intense geomagnetic storms at Earth. The events in early May and in late October were seen by ACE sensors to be co-mingled with solar wind streams. The result was very pronounced substorm events, intense relativistic electron enhancements, and massive buildups of nitric oxide (NO) in the upper atmosphere. We use the PIXIE instrument onboard POLAR to obtain global views of $2-12$ keV x-rays impacting the upper atmosphere. This gives a good measure of relatively low-energy electron precipitation into the atmosphere. The LICA sensor onboard SAMPEX measures $E > 25$ keV electrons in a high-inclination, low-altitude orbit and gives a direct in situ measurement of medium-energy precipitating electrons. Finally, the Student Nitric Oxide Explorer (SNOE) spacecraft measures the NO production in the lower thermosphere. Production of NO is compared with the spatial extent and time variability of energetic electron inputs to the atmosphere. The combination of available space platforms allows disturbances from the sun to be traced to the atmosphere and to assess quantitatively the energy transport throughout the Sun-Earth system during major events.

S17-14

UPPER MESOSPHERIC AND LOWER THERMOSPHERIC MANIFESTATONS OF A STRATOSPHERIC SUDDEN WARMING EVENT OVER EUREKA CANADA (80 N)

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We have examined lidar and airglow data and National Weather Service analysis fields for a stratospheric sudden warming event in February 1993. The lidar and airglow measurements recorded temperature changes in the mesosphere and lower thermosphere over Eureka, Canada (80°N). In addition, the event was simulated by the National Center for Atmospheric Research TIME-GCM. The observations, analysis fields and the simulation results taken together clearly indicate a connection between the stratospheric warming of February 1993 and alternating regions of cooling and warming above the main warming in the lower stratosphere (however, movement of the polar vortex complicates the interpretation for the second of two warmings episodes in the upper stratosphere during the event). The sudden warming was associated with cooling observed in the OH airglow and predicted by the model. This cooling preceded the warming in the lower stratosphere.

S17-15

PLANETARY WAVE MODULATION OF NOCTILUCENT CLOUDS AND PMSE

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Noctilucent clouds and PMSE (polar mesosphere summer echoes) are two closely related phenomena caused by the extremely low temperatures at the summer mesopause. PMSE are modulated by 12 h, 24 h and 5-day cycles. The former two are most likely due to tidal temperature fluctuations, whereas the latter correlates with 5-day planetary waves, with PMSE (at 80 – 90 km height) being more prevalent when the coldest parts of the planetary waves are observed in the lower mesosphere (60 km height) at the same location (*Kirkwood and Rechou, GRL* 1998). Noctilucent clouds over north-west Europe also show a five-day modulation, correlated however with the warmest parts of the 5-day planetary waves at the heights below. Numerical simulations of 5-day planetary waves by *Geisler and Dickinson* (*J. Atmos. Sci*, 1976) predicted that, under typical summer stratospheric wind conditions, a high-amplitude ducted wave would appear in the mesosphere at high latitudes, with a phase reversal compared to the mid-latitude stratosphere. We use meteor and MST radar wind measurements together with UKMO global meteorological assimilations to test whether such a ducted wave can explain the apparently contradictory modulations of PMSE and noctilucent clouds. The ocurrence of noctilucent clouds also shows a strong decadal modulation. We therefore test to what extent this variation can be explained by year-to-year changes in planetary-wave activity.

S17-16

THE COUPLING OF TIDES AND PLANETARY WAVES IN THE MLT REGION

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One of the most striking features of tides and planetary waves observed in the MLT region is the great variability they display on time scales of a few days to a few weeks. Although a number of factors undoubtedly contribute to this variability, it is now recognised that a significant component may arise from wave-wave interactions. Local interactions may be caused by the modulation of gravity-wave momentum fluxes at planetary-wave periods, which in turn act to modulate tidal amplitudes. However, large-scale modulation of tidal amplitudes appears at least partly to originate in non-linear interactions between the tide and planetary waves. A number of observational studies, including a recent large-scale PSMOS experiment, have investigated this mechanism and suggest such interactions occur with a wide range of planetary-wave modes. Modelling studies are also now investigating this phenomenon. Recent observations and modelling work have also suggested that similar non-linear interactions occur between different members of the planetary-wave field. This paper will review these processes and point to a number of unresolved problems.

S17-17

MF RADAR OBSERVATIONS OF MOTIONS WITH PERIODS NEAR 12 HOURS IN THE MESOSPHERE AT HIGH NORTHERN LATITUDES

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We present MF radar measurements of winds from Poker Flat, Alaska (65N, 147W) and from Andenes, Norway (69N, 16E). Continuous data are available since October 1998 from Poker Flat and since January 1998 from Andenes. Based on the data records obtained thus far, the 12-hr motions from these high latitude sites exhibit a strong seasonal variation with an amplitude maximum near the summer solstice. During the summer solstice the large 12-hr period amplitudes are intermittent in time and confined in height, peaking at a height above the westward summertime jet where the zonal wind changes sign. The seasonal dependence and altitude structure of the high northern latitude 12-hr motions are similar to those of the so-called 12-hr wave, a zonal wavenumber-1 motion which has previously been observed in the Antarctic. The longitudinal separation of the Poker Flat and Andenes radars allows us to study the zonal wavenumber structure and further investigate the 12-hr wave hypothesis.

S17-18

STUDY OF TIDAL DYNAMICS IN THE ARCTIC MESOSPHERE AND LOWER THERMOSPHERE BY THE EISCAT RADAR AND COORDINATED GROUND-BASED FACILITIES

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The EISCAT radar and coordinated ground-based observations in the arctic region have been contributing to study atmospheric tidal dynamics in the polar mesosphere and lower thermosphere. Particularly interesting here are the unresolved issues relating to the behaviors of atmospheric tides at polar latitudes, *e.g.*, occasionally observed propagating characteristics of diurnal component at winter-time when background zonal wind is enhanced, summer-time prevalence of non-migrating semidiurnal component due possibly to the interaction with stationary planetary waves, and signature of terdiurnal component which shows shorter vertical wavelength suggestive of coupled diurnal component. These signatures might possibly be the outcome of interaction of wave-mean flow or wave-wave nature in the course of propagation from the denser neutral atmosphere below. Also evident in these tidal oscillations are the effect of geomagnetic disturbances to the neutral wind field and hydromagnetic tide excited in the lower thermosphere. Even the meteor trail drift and echoing of some radars might sometimes be subject to agents characteristic of high latitude mesopause regions. The essential keys to uncover this global-scale tidal waves are both the globally or longitudinally/latitudinally collaborative and multi-instrumental observations which can compare different physical quantities with different altitude coverage. A brief mention will be given to how far these have been clarified by now and what might be resolved in coming years.

S17-19

DYNAMICS OF EQUATORIAL MESOSPHERE OVER PONTIANAK

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Recent studies have revealed that the behavior of the equatorial atmosphere is very important for the understanding of the global structure of atmosphere dynamics. Through collaboration between Indonesia, Japan and Australia, an MF radar has been established at Pontianak (0.03°S, 109°E) since November 1995 for measurements of atmosphere dynamics in the equatorial mesosphere and lower thermosphere. It will be also be used to examine planetary scale oscillations as well as gravity waves. The radar which operates at 1.98 MHz provides wind velocities in the altitude range 60 – 100 km during day-time and 70 – 100 km during night, with a height resolution of 2 km and a time resolution of 2 min.

S17-20

HIDDEN TREASURES BENEATH THE TIDES: UNCOVERING REGIONAL AND PLANETARY STRUCTURES IN SATELLITE NIGHTGLOW MAPS

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The migrating tides, by causing strong vertical advection, impose a pronounced latitude/local time structure on the brightness of the nightglow emission layers in the upper mesosphere. Other processes such as gravity waves and planetary waves also produce significant vertical advection and diffusion. Inferring the presence and true amplitude of these non-tidal events in satellite nightglow data first requires that their signature be isolated from that of the dominant tidal pattern, since the apparent amplitude of these non-tidal modulations depends strongly on the tidal and mean state background in which they occur.

Near-global maps of the (0,0) Atmospheric band molecular oxygen nightglow have been collected with HRDI/UARS at a very high horizontal resolution of $\sim$ 50 km since March 1996. A contrast enhancement technique often used in image processing is applied to these nightglow maps to rescale the observed brightness, effectively removing the background signal produced by the zonal mean state and migrating tides. This analysis yields corresponding near-global maps of a residual brightness signal from which the strength and global morphology of planetary waves and gravity wave activity can be inferred. Spatial patterns which are highly suppressed or not readily apparent in the raw nightglow images are readily discerned in the residual maps. The spatial structures revealed in the residual maps are being studied in comparison with a variety of concurrent ground-based nightglow observations to further interpret these non-tidal features as viewed by satellite. The initial results of these comparisons will be presented.

S17-21

STUDY OF HORIZONTAL AND VERTICAL STRUCTURE OF THE MESOPAUSE REGION WITH THE MU RADAR AND OPTICAL OBSERVATIONS

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The atmospheric radars are capable of obtaining vertical profiles of wind velocity and its temporal variations. On the other hand, optical observations of airglow have no vertical structure information but can observe horizontal structure of the airglow and dynamical parameters such as wind and temperature. The MU radar has been operated to receive meteor echoes in order to derive wind and relative temperature and their temporal and height variations in the MLT region (80 – 100 km). The MU radar meteor observation has very good height resolution (1 km) compared to other radars in the same height region. We have applied a new technique of radar meteor wind reduction for deriving horizontal structure of wind velocities using the widely spread horizontal extent of meteor echo locations observed with the MU radar (200 km in diameter). This technique can be used to study the horizontal scale of atmospheric waves especially in discriminating gravity waves with periods of 12 and 24 hours from global tidal wind. Also, comparisons with optical observations have been carried out. The effect of the horizontal wind gradient to the airglow image pattern has been clearly shown in the case of gravity wave break event in December 1995. The detailed comparison of the FPI derived wind and meteor winds are also undergoing with the MU radar and FPI of Nagoya University, which sometimes suggests the effect of height variation of airglow emission.

S17-22

AIRGLOW OBSERVATIONS OF GRAVITY WAVES AT ADELAIDE, AUSTRALIA

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Airglow observations of 730 nm OH and 557.7 nm O emissions were collected on a continuous basis using a three field photometer located at Buckland Park near Adelaide, Australia from April 1995 to the April 2000. Observations were made at night whenever the moon was not up. To identify short period (< 3 hours) wave activity a cross spectral analysis was performed on each night's data where cloud impact was minimal. The effect on the data of the passage of the Milky Way though the instrument's field of view was removed prior to this analysis using a wavelet filter method. The resulting wave parameters are analysed for seasonal variability and used to build up a climatology of gravity wave parameters over the 5 years of observation.

A colocated MF radar has been operating in spaced antenna mode providing wind data concurrent with the optical observations for most of the acquisition period. When available the wind data allowed calculation of the intrinic parameters for waves identified in the optical data. The seasonal variablility of these parameters is investigated.

S17-23

OBSERVATIONS OF THE MESOPAUSE REGION BY MULTI-LIDAR SYSTEM

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Mesospheric Na layers have been observed routinely since November 1991 with a Na ground-based lidar of Tokyo Metropolitan University (TMU) at Hachioji, Tokyo (35.6 N, 139.4 E). Though the sporadic Na layers have been rarely observed at other lidar sites in the mid-latitude, we have been able to recognize a lot of events of the sporadic Na layers. By examining the correlation between the sporadic Na layers and the sporadic E layers, we can find out the considerable relation between them. Owing to understanding the formation mechanisms of the sporadic and normal metallic layers, it is important to observe simultaneously them with Ca ion layers and temperature profiles in the mesopause region. We develop the resonance scattering lidar system for measurement of mesospheric metallic species and temperature. For observations of the K, Fe and Ca ion layers, we develop the flashlamp pumped Ti:sapphire laser injected by the seeder that consists of a external cavity laser diode. On the other hand, the sophisticated dye lidar system is also developed for Na temperature measurement. The laser system consists of a pulsed dye oscillator and an amplifier system injection-seeded by a stabilized cw ring dye laser. The injection-seeder consists of the single mode ring dye laser locked to the Na fluorescence line with the wavemeter and the Na vapor cell. This laser system can generate the high pulse energy (more than 100 mJ/pulse) keeping up the narrow bandwidth (about 0.1 pm). This paper discusses the details of the laser design and the results of the observation by these lidar systems.

S17-P01

A NUMERICAL EXPERIMENT ON 3D MOTIONS AROUND THE MID-LATITUDE TROPOSPHERIC JET

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A numerical experiment on the dynamics of the mid-latitude tropospheric jet is done with an idealized global circulation model in order to understand the exchange process between the stratosphere and the troposphere through transient motions related with the fluctuating tropospheric jet.

It is a dry-atmosphere model of the troposphere and stratosphere with a Newtonian-type radiation scheme for meridional differential heating. An idealized surface topography of zonal wavenumber two is introduced to make zonal asymmetry and its amplitude is changed from 0 m to 1000 m for 6 runs as an experimental parameter.

For a sufficient amplitude of the topography, nonlinear interactions among zonal mean zonal flow, forced planetary waves and baroclinic disturbances produce a localized jet structure which fluctuates irregularly with time-scales of $O(1-10$ days). An analysis of three-dimensional flow of the time-averaged field shows that ageostrophic motions across the tropopause have opposite meridional circulation between the entrance and the exit regions of a local jet core; direct circulation at the entrance region, while indirect at the exit region. These are consistent with the traditional picture.

However, movies of some dynamical fields, such as the potential vorticity field on an isentropic surface, horizontal wind speed, vertical velocity, and so on, show large fluctuations in time and space. Any snapshot of the flow field does not look like the time-averaged field, indicating that the traditional method separating into a time-averaged basic state and deviation from it has much limitation of the application to the flow field with large fluctuations.

Three-dimensional analysis of such fluctuating flow fields with contemporary computer graphics tools gives us a new insight into the time variations of the stratosphere-troposphere exchange around a mid-latitude tropospheric jet core.

S17-P02

MST RADAR OBSERVATIONS OF TROPICAL TROPOPAUSE OVER GADANKI (13.450 N, 79.180 E)

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Tropical tropopause, very distinct from that of mid- and high-latitudes, plays very important role in Stratosphere-Troposphere Exchange (STE). Several experiments, with fine range resolution ($\sim$ 150 m), have been carried out using Indian MST Radar at Gadanki, a tropical station in India, to study the characteristics of tropical tropopause. Height-Time-Intensity (HTI) maps for vertical beam signal-to-Noise Ratio (SNR), that arises mainly due to Fresnel reflection/scattering from stable laminae and clear air turbulence, clearly revealed the multiple layer structure of the tropopause. These structures are observed to vary both in height and time and 'weaken' during passage of tropical convection events. Such weakening of stable layer structures are observed to be associated with the enhanced mass-flux across the tropopause, providing an evidence for STE. MST radar observations have been used to determine the height of the tropical tropopause, independently, by making use of the radar equation and WMO definition for height of the tropopause. A comparison between the height of the tropopasue, determined from radar and routine radiosonde observations shows good correlation between the two. The spectral analysis of height of the tropical tropopause clearly shows the presence of three prominent oscillations with periodicities (a) $50-70$ (b) $30-50$ and (c) $10-20$ days. Similar analysis of zonal and meridional winds and temperature also shows presnce of these oscillations. Analysis of amplitude corresponding to these oscillations clearly shows the leakage of energy from troposphere to stratosphere. Results obtained from special observations carried out during Solar Eclipse are also presented.

S17-P03

COSMIC RAY INFLUENCE ON CHEMICAL COMPOSITION OF THE MIDDLE ATMOSPHERE: DATA ANALYSIS AND PHOTOCHEMICAL MODELING

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Long-term measurements realised by Russian satellite polar system of solar proton fluxes, galactic cosmic ray intensity in the stratosphere (balloon long-term measurements at several Russian stations), and global ozone data were used to investigate the ozone response to cosmic influence of such kind. It was taken into account that cosmic rays (galactic and solar origin) as a high energy particles produce odd nitrogen and hydrogen species in the atmosphere and realise additional link between solar-terrestrial processes and atmospheric chemistry including photochemistry of ozone layer of the Earth. There were two parts of this study: data analysis and photochemical calculations. The first part of the study has revealed a clear total ozone response (yearly averaged data sets were used for regression analysis) to strong solar proton events (SPEs) in 1972, 1989 and 1991. The revealed effect depends on the latitude: negative for high latitude (in accordance to chemical mechanism of ozone destruction), and positive at the low latitudes (in the contrast to the photochemical theory). The decadal response of total ozone to galactic cosmic ray (GCR) influence wsa revealed also for three points of balloon GCR measurements in the stratosphere: Murmansk (69 N), Moscow (57 N) and Mirny (69 S). It was found that ozone response is in phase with decadal variations of GCRs (also in the contrast to idea of catalytical ozone destruction by NO_X). Time-dependent 1-D photochemical model was used to understand the situation. Model simulations shown that the effect of GCRs on ozone placed in the lower stratosphere and troposphere looks like the situation with aircfafts emission and needs more complicated chemistry than in the stratosphere. So GCR increases ozone content in the atmosphere.

S17-P04

MODELING THE EFFECTS OF THE OCTOBER 1989 SPE ON MIDDLE ATMOSPHERIC NO AND OZONE USING A DETAILED ION AND NEUTRAL CHEMISTRY MODEL

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Solar proton events and electron precipitation affect the middle atmosphere constituent concentrations. Ionization caused by precipitating particles leads to enhanced production of some important minor neutral constituents (such as NO) through reaction chains in which ionic reactions play an important role. Therefore, when calculating effects of particle precipitation on the atmosphere and ionosphere, one has to take into account the reactions that couple the ionic and neutral constituents.

Finnish Meteorological Institute and Sodankyla Geophysical Observatory have developed a detailed ion and neutral chemistry model of the middle atmosphere that can be used to investigate the effect of particle events on several minor constituents. Our steady state model, which is based on the Sodankyla Ion Chemistry model, contains 56 ion species, the most important neutral species, and over 300 chemical reactions.

As a first test to our model we have modeled the effects of the October 1989 solar proton event on the middle atmosphere. Our results show that increase in ionization due to protons leads to significant production of NO and subsequent loss of ozone. Comparison with EISCAT incoherent scatter radar measurements gives a reasonably good agreement.

S17-P05

VARIATIONS IN SOLAR UV-B RADIATION AT A TROPICAL SITE DURING OCTOBER – DECEMBER MONTHS

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Direct component of solar ultraviolet radiation in the wavelength band 290 to 320 nanometer (nm) reaching the surface of the earth was measured using a multi-filter photometer mounted on a sun-tracker. The measurements were carried out over the years 1982 to 1992 at a tropical site Thiruvananthapuram (Trivandrum) (8.33°N, 76.5°E), India. The measured flux shows an annual variation similar to the visible radiation, except during the months October to December. During the period October to December, a decrease in the UV-B flux has been noticed in all the years of measurement. An increase in ozone due to transport associated with monsoon winds could be a cause for this anomalous decrease in the UV flux. At the same time, the period in which the decrease has been noticed coincides with the southern summer and the Antarctic ozone depletion (hole) period. In one year when the Antarctic ozone depletion was less, the anomalous decrease has also been found to be low. Does it indicate a possible linkage between the Antarctic ozone depletion and the decrease in the solar UV-B flux (or increase in ozone) in the tropical station is to be understood. A physical mechanism for such a cross-equatorial linkage as of now is not known, but tele-connection possibility may not be ruled out.

S17-P06

A MESO-SCALE SIMULATION OF GRAVITY WAVES GENERATED BY CUMULUS CONVECTION DURING TOGA-COARE

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Cumulus convection is known to generate gravity waves, and thought to be the main source of the gravity waves in the tropical middle atmosphere. These convectively generated gravity waves are supposed to drive low frequency circulation in the middle atmosphere. In order to investigate the gravity waves, we have conducted a three dimensional simulation by using a nonhydrostatic meso-scale model, ARPS (Advanced Regional Prediction System). The vertical grid of the model was set to cover the stratosphere with fine resolution. Boundary condition and large-scale forcing were taken from Tropical Ocean Global Atmosphere-Coupled Ocean Atmosphere Response Experiment (TOGA-COARE) observations. The model was run for a few weeks to cover a full range of gravity wave frequencies. Gravity waves spontaneously generated in the model were analyzed by using various statistical methods and compared with TOGA-COARE soundings. We will further try to identify their forcing and construct an empirical model of the forcing-response relationship to facilitate parameterization of convectively generated gravity waves.

S17-P07

INSTABILITY OF ACOUSTIC GRAVITY WAVES IN A NONISOTHERMAL ATMOSPHERE

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In this work we discuss the model problem of finding the lowest mode frequency of the fast branch of acoustic gravity waves. The cut-off frequency in a nonisothermal atmosphere is found in the analytical approximation of the atmosphere temperature we found. On the basis of the solution of this model problem on finding the lowest mode of the acoustic gravity waves, we conclude that in a nonisothermal atmosphere the cut-off frequency can be smaller than the Brunt-Vaisala frequency. The acoustic gravity waves can be unstable in this case. The increment of this instability is estimated. It is shown that the nonlinear wave saturation affects the cut-off frequency, and this feature is important for the instability region. This phenomenon must be observed at middle-atmosphere altitudes.

S17-P08

THE MUTSI (MU RADAR TEMPERATURE SHEETS AND INTERFEROMETRY) CAMPAIGN FOR LAYERED-TURBULENCE STUDIES

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Thin turbulent layers are ubiquitous in stable parts of the earth's atmosphere as observed remotely with MST (mesosphere-stratosphere-troposphere) radars and in situ with high resolution balloons. Recent observations by French balloons with height-resolution of 8 cm have resolved the temperature layers to several meters in thickness. However, very little information has been yet obtained on their spatial and temporal structure or their effects on meso-scale stable stratifications of the atmosphere. No doubt, more observations are crucially required for a better understanding of vertical transport of energy, atmospheric constituents and aerosol in and outside the layers.

The MUTSI (MU radar Temperature sheets and Interferometry) campaign was conducted in May 2000 to make simultaneous and comparative observations of turbulent layers and temperature sheets, by launching ten French capsphere-type balloons equipped with instrumented gondolas near the MU radar. The MU radar was operated by interleaving different observational modes: Doppler beam swinging, Frequency domain interferometry, Frequency radar interferometric imaging, and Spatial domain interferometry techniques. It is expected, owing to this campain, that totally original and complementary data sets are collected.

An outline of this campaign will be presented with preliminary results of the French balloons and the MU radar.

S17-P09

COUPLING BETWEEN ATMOSPHERIC PRESSURE AND ATMOSPHERIC ELECTRICAL CONDUCTIVITY

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Atmospheric electrical conductivity measurements were carried out at the surface for about three years at three environmentally different locations in a geographic region, in southern India. One site was at a coast with rich radioactive deposits, the second was also coastal but with negligible radioactive deposit and the third was an inland station with negligible radioactive deposit. The conductivity variations at all the three sites showed a semi-diurnal variation which anti correlates with atmospheric pressure variation. The significance of the relation is that a variation of the order of 100 % in conductivity is anti-correlated to a diurnal variation of about 0.4 % in atmospheric pressure. This relationship is contrary to the belief that conductivity is affected by local agencies of ion production and destruction only. Measurements at the sites of radioactivity differing by about hundred times or more of natural radioactivity shows the relationship is not affected by the strength of natural radioactivity too.

S17-P10

MODELLING THE CONDUCTIVITY OF THE MIDDLE ATMOSPHERE

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Conductivity of the atmosphere is governed by (i) Ionization of the atmospheric constituents, (ii) Ion-chemical reactions that convert the electrons and molecular positive ions into complex ions, (iii) Loss of these charged species through attachment with the ambient aerosols, (iv) Loss mechanisms for the molecular ions (small) and aerosol ions (large or heavy) through mutual recombination of the oppositely charged species and (v) Mobility of small ions. The physical entities controling these processes are not the same and vary vastly both in nature and magnitude in the middle atmosphere. Large variability is seen in the sources for aerosols and/or particulates which modulate the atmospheric conductivity. Tropospheric aerosols arise from natural and anthropogenic sources and are subjected to meteorological influences. In the stratosphere, the steady background aerosols are enhanced from volcanic activity. In addition, smoke and dust particles from meteoric ablation descend down and add to stratospheric aerosol loading. Meteoric dust particulates act as sinks for electrons and ions in the mesosphere particularly at higher heights.

While a simplified ion-aerosol model is satisfactory for modelling the stratospheric conductivity, a heterogeneous ion-chemical model involving multiple charging of meteoric dust particles is necessary for modelling the mesospheric conductivity. Modelling the temporal and spatial variations of tropospheric conductivity is important in view of the pollutant generated aerosols which modulate the background conductivity. The tropospheric conductivity is prone to meteorological effects since the microphysical processes governing the growth, decay and removal of aerosols are influenced by temperature, humidity, wind etc. The model results on conductivity at the earth's surface incorporating ionization from environmental radiation (Radon and its daughter products), stratospheric conductivity for background aerosols and enhanced aerosols (from volcanic sources), and mesospheric conductivity from a heterogeneous ion-chemical model with meteoric dust are presented. It is desirable to use a unified aerosol-ion-chemical model for the tropo-strato-mesosphere.

S17-P11

MODELLING THE DISTRIBUTION OF CARBON DIOXYDE IN THE MESOSPHERE AND LOWER THERMOSPHERE

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The main cooling process in the Mesosphere-Lower Thermosphere (MLT) is radiative emission by carbon dioxyde in the infrared. Estimating its importance requires a good knowledge of the distribution of CO_2 throughout the MLT. Results from an interactive 2D-model are presented, showing the altitude, latitude and seasonal variations of CO_2 between 60 and 120 km of altitude. These results are compared to available observations and results from other models. Using the model, we show several key processes for a proper evaluation of CO_2 distribution. These include molecular diffusion, penetration of solar Lyman α line and temperature dependence of the photodissociation cross-section. The laboratory and field measurements required to understand CO_2 distribution are discussed.

S17-P12

THE ROLE OF CHARGED DUST IN MESOSPHERIC ELECTRICAL STRUCTURE

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There are direct evidences for the existence of both positively and negatively charged dust particles in the lower and upper mesosphere. Extremely low effective conductivity is predicted in the region where both positive and negative charges carried by the dust exceed the charges carried by ions and electrons. This condition is similar to that leading to formation of polar mesosphere summer echoes (PMSE). The predicted effective conductivity of the mesosphere is about two to three orders of magnitude less than the measured ion conductivity. This difference appears to be explained by instrumental reasons. The extremely low effective conductivity of the mesospheric dusty plasma can explain the existence of V/m vertical electric fields observed both in the lower mesosphere and in the vicinity of noctilucent clouds and PMSE. Gravitational sedimentation of charged dust as well as currents of the global atmospheric electric circuit and precipitating high-energy electrons and protons can produce the observed V/m fields under these conditions. The proposed theory allows understanding the difference between mesospheric electric field rocket data obtained with the help of electric field mill and double probe techniques as well as the observed behavior of the mesospheric vertical electric fields: their large variability, universal diurnal variation, increasing during solar proton events and geomagnetic disturbances.

S17-P13

SHORT-TERM VARIABILITY OF 1 AND 1/2 DAY-PERIOD WIND OSCILLATIONS OBSERVED WITH MF RADAR AT POKER FLAT, ALASKA

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MF radar observation at Poker Flat, Alaska, has started since October 1998, as part of "Alaska Project", which is a name of cooperative research program between Communications Resaerch Laboratory of Japanese government and Geophysical Institute of University of Alaska, USA. We have studied short term variability of 1 and 1/2 day-period wind oscillations at the 80-km height in winter 1998/1999. For a longer time scale, the 1-day and 1/2-day component phases by 10 day-window fitting show relatively stable phases for the winter. By sinusoidal curve fitting with a 24-hr window sliding by 6 hr, for January–March 1999, amplitude of the 1/2-day component showed larger variability of a few to ~ 30 m/s with time scales $<$ several days. The 1/2-day waves with short vertical scales of $40 - 50$ km in late February showed possible correlation with 5 day-period meridional wind variation, suggesting the tidal-mean wind coupling with such a short time scale. The 1-day component amplitude is generally smaller than 20 m/s with smaller variability for the three months, except for a significant amplitude enhancement up to 70 m/s in $21 - 23$ January. A proton flux increase (at > 30 MeV) is observed by the GOES-10 geostationary spacecraft during the days. It is suggested that for understanding variability of the polar mesosphere especially with time scales $<$ several days, the coupling processes of mean wind/planetary waves and tides should be important, and also possible effects of energetic particle precipitation might play some roles.

S17-P14

A NEW MF RADAR AT SYOWA STATION, ANTARCTICA

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An MF radar was installed at Syowa station, Antarctica (69 S, 39 E), and has been almost continuously observing wind fields with a fairly good quality since late March 1999. At times, echo returns from altitude as low as 50 km are detected. The observed wind data, obtained through a full correlation analysis (FCA), reveals the behavior of atmospheric gravity waves, tides, longer-period waves and a clear seasonal variation of background winds.

In addition to the FCA, the radar has been also applied for meteor echo observations. The same raw data is used for both FCA and meteor analysis regarding it as the sources of partial reflection echoes and meteor echoes, respectively. Detected meteor echoes show a height distribution with a peak around 100 km enabling wind velocity estimates at least up to 110 km. The major disadvantage of MF/meteor observation is that meteor echoes are rarely observed when partial reflection echoes are relatively strong and block meteor echoes. However, during the period of polar night, considerable number of meteor echoes are received throughout a day when the return from the E region is weak. Even in mid-summer meteor wind observation can be successfully done quite often at hours centered at the local mid-night. Comparison of the wind values from the two methods suggests that some discrepancy still remains to be resolved.

It must be noted that global collaboration with longitudinal chain of MF radars in Antarctica, TIMED satellite, and conjugate observations made in Arctic region are expected to work well in clarifying the wave dynamics in the polar upper atmosphere.

S17-P15

COMPARISON OF SHORT-PERIOD GRAVITY WAVES OBSERVED BY CCD IMAGERS AT SHIGARAKI AND RIKUBETSU FOR 1998 – 2000

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Simultaneous observation of short-period gravity waves has been carried out using three all-sky cooled-CCD imagers at Shigaraki (34.9 N, 136.1 E) and Rikubetsu (43.5 N, 143.8 E). The imagers have five filters on a wheel, a fish-eye lens which has a field-of-view of 180 degrees, and a back-illuminated cooled-CCD camera with 512×512 pixels. Airglow images of the OH-bands and OI-557.7 nm line are obtained with a time resolution of 2.5 – 5.0 min at Shigaraki and 5.5 min at Rikubetsu. The two sites are separated in a horizontal distance of about 1200 km. These imagers have been operated automatically since October, 1998.

In this presentation, we will classify characteristics of the gravity waves observed in the airglow images at Shigaraki and Rikubetsu from October 1998 to February 2000. The horizontal wind data obtained by the two MF radars at Wakkanai (45.4 N, 141.7 E) and Yamagawa (31.2 N, 130.6 E) will be also used to investigate propagation features of the observed gravity waves.

S17-P16

AIRGLOW IMAGING OBSERVATIONS OF GRAVITY WAVES WITH CCD IMAGERS

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Airglow imaging observation is suitable for studying horizontal structure and horizontal propagation of gravity waves in the mesospause region, especially of the waves with short period (< 2 hours) and small scales (< 100 km wavelengths), which is complementary to the radar observations. Radio Science Center for Space and Atmosphere (RASC; previously Radio Atmospheric Science Center), Kyoto University has developed OH CCD imager and All-sky CCD imager (with National Institute of Polar Research). These imagers have been installed at the MU radar site (Shigaraki MU obseravtory, 34.85N,136.11E), and carried out observations for more than two years with the MU radar, and clarified behaviors and seasonal variations of short period gravity waves in the mesopause region. These imagers have been improved to be operated at a remote site under a control through the networks. The first purpose is to carry out simultaneous airglow observations with two and more imagers in a distance of several tens of km, in order to triangulate and measure the height structure of gravity wave modulation of airglow. The second is to be installed in a tropical sites in Indonesia and study gravity wave activity near the deep convection area in the equatorial region. In this paper the improvement of data taking and control system of the imager for a remote site observation is introduced. The results of two station observations and a plan of observations in the equatorial region will also be presented.

S17-P17

AIRGLOW OBSERVATIONS OF GRAVITY WAVES AT ADELAIDE, AUSTRALIA

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Airglow observations of 730nm OH and 557.7nm O intensity were collected on a continuous basis using a three field photometer located at Buckland Park near Adelaide, Australia from April 1995 to April 2000. Observations were made at night during moonless periods. Long period variations in the airglow intensity identified in the observations are related to MF radar wind observations of long period waves made at the same location.

S17-P18

A NEW LIDAR OBSERVATION OF THE MIDDLE/LOWER ATMOSPHERE AT SHIGARAKI (35 N, 136 E)

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The MU radar (Middle and Upper atmosphere radar) in Shigaraki, Japan is a powerful atmospheric radar to be used as both MST (Mesosphere-Stratosphere-Troposphere) and IS (Incoherent Scatter) radars, and has been operated for a long time since 1984 for the study of lower- middle- and upper atmosphere dynamics. However, the height region between 25 and 60 km is unable to be measured because of very low scattering signals from the atmosphere. A lidar system has been planned and installed in order to fill this data gap in the center of middle atmosphere and to observe the whole middle atmosphere dynamics between the troposphere and upper atmosphere. The main target of the system is Rayleigh scatter from the middle atmosphere to derive the neutral temperature. The system is equipped with a YAG laser (600 mJ, 50 Hz at 532 nm SHG) and two telescopes (82 cm and 35 cm). Besides Rayleigh/Mie scatter detection channel, N_2 and H_20 Raman scatters are monitored in order to derive temperature and humidity in the lower atmosphere. Another laser system for 589 nm sodium resonance scatter developed by Shinshu University is also equipped in order to monitor atomic sodium density variation with a high time and height resolutions. This new system was installed at the Shigaraki MU observatory in March 2000. Initial results will be presented in the paper as well as comparative observations with the radar and radiosondes.

S18-01

THE SUNSPOT CYCLE AND THE LOWER ATMOSPHERE

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Based on data of 4 solar cycles, we have examined the global structure of the signal of the 11-year sunspot cycle (SSC) in the stratosphere and troposphere, using correlations between the solar cycle and heights and temperatures at different pressure levels. We expanded this work to show the differences in the geopot. heights between maxima and minima of the SSC. We show the global signal, stress the differences between the hemispheres, and point out that the solar signal in the lower northern winter stratosphere is strongest during January/February in the east phase of the QBO.

S18

S18-02

CHARACTERISTICS OF SHORT-TERM AND LONG-TERM VARIATIONS OF THE ARCTIC POLAR VORTEX

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Variables to describe the properties of the polar vortex in each winter/spring season were introduced based on the Ertel's potential vorticity maps, which are the strength, duration, radius and unstableness of the vortex. The vortex indices for the winter/spring from 1959 to 1997 were calculated using the NCEP reanalysis data. Positive trends are clearly found in the strength, duration and radius, and a negative trend is shown in the unstableness of the polar vortices. Short-term variations are closely connected with the QBO and long-term variations are made by coupling of the 11-yr solar cycle and the QBO; the Arctic polar vortex was strong, large and stable in the solar inactive phase. Meanwhile, a correlation between the QBO and vortex indices is weak or weakly negative in the solar active phase. Timing between the vortex periods and QBO also modulated the variations of the vortex indices. Vertical structures of the polar vortices and their changes will be also presented.

S18-03

ABOUT THE INSTABILITY OF SOLAR-CLIMATIC RELATIONS

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One of the most confusing facts related to the problem of solar activity influence on weather and climate is the instability of the relations found. Different authors have reported positive, negative or missing correlations between solar and geomagnetic activity parameters and meteorological elements in the 11-year solar cycle. A compilation of all published results shows that the cases of positive and negative correlations are fairly well grouped with the sign of the correlation depending upon the studied period and changing in consecutive secular solar cycles. This conclusion is proved by an investigation of reconstructions of global, hemispheric and zonal temperatures, as well as of data from individual meteorological stations with long measurement records covering almost 300 years: the correlation between sunspot numbers and surface air temperature is positive in the 18th century, negative in the 19th and positive again in the 20th century. There is, therefore, some factor changing in consecutive secular solar cycles, that determines the way in which changes in solar activity affect climate. A candidate factor is shown to be the North-South solar asymmetry: when the Northern solar hemisphere is more active the correlation between solar activity and surface air temperature in the 11-year solar cycle is positive, and when more active is the Southern hemisphere, the correlation is negative. A similar dependence of the sign of the correlation on the solar hemisphere affecting the Earth has been found earlier for time-scales of the order of days. However, it is still unclear in what way the two solar hemispheres might differ, and how this supposed difference could reverse the way in which solar activity influences terrestrial climate.

S18-04

MODELLING THE EFFECTS OF SOLAR CYCLES AND SOME COMPARISONS WITH OBSERVATIONS

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Variations of several percent in the UV part of the solar spectrum occur in response to the 11-year solar activity cycle and also due to the 27-day solar rotation. These give rise to a similar variability in ozone and possible feedback effects through radiation and transport. Analyses of stratospheric temperature trends indicate that the impact of the solar cycle is a significant fraction of the decadal trend due to greenhouse gas increases. Hence it is important to quantify and understand the influence of solar variability on stratospheric ozone and temperature. In turn this could lead to improved understanding of the interaction between solar efects and climate.

Results will be presented from simulations of The Met. Office coupled chemistry-climate model. The model has 64 levels from the ground to 0.01 mbar and contains a complete range of chemical reactions allowing representation of all the main ozone formation and destruction processes. By resolving the whole of the stratosphere and most of the mesosphere, and in three dimensions, the model is able to simulate possible dynamical feedbacks, such as changes in global mean meridional circulation, important for ozone transport. Improvements to the model have been made to simulate the effects of solar variability on both photodissociation and radiative heating rates.

Two experiments will be described. In the first a 27-day oscillation is included with an amplitude spectrum determined using data from UARS SOLSTICE. Preliminary results with 2 year simulations show that the model correctly captures the observed tropical ozone sensitivity and downward phase propagation. The second experiment involves two 10-year simulations, with top of the atmosphere solar fluxes corresponding to the maximum and minimum of the 11-year solar cycle. The model response in ozone and temperature will be compared with satellite observations.

S18-05

SOLAR ACTIVITY INDUCED CHANGES IN THE LOWER AND MIDDLE ATMOSPHERE

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Influence of solar activity in the 11-year cycle in atmospheric parameters and the circulation pattern of the lower and middle atmosphere has been studied based on radiosonde and rocket observations for at least two solar cycle periods. Further detailed studies using NCEP/NCAR reanalysis data have also been carried out at selected levels in the troposphere and stratosphere at various latitude zones. Atmospheric pressure is found to be highly sensitive to solar changes, which is positive at all height levels. The response of temperature to solar activity is directly associated in the region of positive lapse rates (troposphere and mesosphere) and is inversely in the stratosphere. The changes in temperature associated with solar activity is lower in in the dense troposphere and higher in the mesosphere. The temperature changes from its mean value of the order of $1-2$ % in the troposphere, whereas it changes to $6-8$ % in the mesosphere for a change of 100 units of solar radio flux. The circulation pattern of the lower and middle atmosphere also found to be affected in accordance with the solar activity. The study reveals that there is an external forcing exist during the period of high solar activity which compresses the earth's atmosphere. When the atmosphere is forced externally, the relatively less dense upper layers affected more than the dense lower layers.

S18-06

NONSTATIONARY CYCLES IN C14-DATA AND CLIMATE CHANGES

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C14 data (2500 yr. BC – 1980 yr. AC), global temperature (GT) data (1000 to 1989 yr.) are analysed via MGM method. MGM is capable of making a self-consistent selection of trends from a data set and singling out harmonics with varying phase and amplitude, so one can detect time intervals of development of non-linear processes in data. Deterministic part of the spectrum is derived. Trend is the most prominent. The powerest non-stationary sinusoid in spectrum at $T = (1100 \pm 150)$ yr. has phase crashes for defined years. The highest speed of phase changes was in ~ 1000 yr. that coincides with the time of the acceleration maximum in the Moon's movement derived earlier in astronomical data. This cycle has two maxima in C14, one of which coincides with the time of the Maunder Minimum (MM). Our analysis shows that this cycle is a part of longer cycles, periods of which are detected. The Sporer and the Wolf minima (SM, WM) are forced by short-periodic changes in C14 ($T < 210$ yr.). Global temperature (GT) data confirm our analysis. MM in GT data is forced by behaviour of non-stationary harmonics of the derived long cycles, SM and WM are caused by the defined short-periodic nonstationary cycles. Characteristics of these cycles are obtained. Forecasting of the future behaviour of C14 and GT is presented and discussed.

S18-07

THE EFFECT OF THE QBO AND THE SOLAR CYCLE ON THE STRATOSPHERIC CIRCULATION IN THE NH AND THE SH

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The relationship between the interannual variability of the winter stratospheric circulation in the northern hemisphere (NH) and the equatorial quasi-biennial oscillation (QBO) has long been studied since the analysis by *Holton and Tan* (1980). When the easterly (E) and westerly (W) phases of the QBO was defined with respect to the equatorial zonal wind at around the 50-hPa level, the deeper and colder circumpolar vortex and the stronger polar-night jet was found in the W than in the E, and most of the major stratospheric sudden warming occurred in the E. These aspects are called "the extratropical QBO" or "Holton-Tan oscillation (HTO)".

On the other hand, It was shown by *Labitzke* (1987) and the following studies that the temperature at the polar lower stratosphere in the northern winter had a positive (negative) correlation with the solar cycle when the analysis was made by using only the data for the W (E). In other words, the winter polar stratosphere tended to be warmer in the W of the solar maximum (Max) and the E of the minimum (Min) than in the W/Min and the E/Max groups.

Accordingly, it is expected that the relationship found by Holton and Tan between the winter stratospheric circulation and the equatorial QBO appears more clearly in the Min and does not in the Max. It was confirmed with the statistical analysis we made by using the data provided by the Stratospheric Research Group at the Meteorological Institute of the Free University of Berlin.

In the southern hemisphere (SH), on the other, the correlation between the extratropical stratospheric circulation and the equatorial QBO is more significant in spring (the season with the largest interannual variability) than in midwinter. The relationship amoung the QBO, the solar cycle and the extratropical stratospheric circulation is also interesting.

S18-08

CONNECTION BETWEEN THE SOLAR CYCLE AND THE QBO: THE MISSING LINK

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Evidence of the solar cycle in stratospheric polar temperature rests on a connection to the quasi-biennial oscillation (QBO) of equatorial wind. New evidence reported here establishes a mechanism for how the solar signature in polar temperature follows from the QBO, which itself is shown to vary with the solar cycle. Equatorial westerlies below 30 mb vary systematically with solar activity, as do equatorial easterlies above 30 mb. Changes in their duration introduce a systematic drift into the QBO's phase relative to winter months, when the polar vortex is sensitive to equatorial wind. Corresponding changes in the polar-night vortex are consistent with the solar signature observed in wintertime records of polar temperature that have been stratified according to the QBO.

S18-09

UPPER ATMOSPHERE HEAT BUDGET OVER THAT LAST TWO DECADES

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The primary heat sources for the upper atmosphere are 1) solar ultraviolet radiation, 2) auroral zone heating due to particle precipitation and electric currents, and 3) dissipation of tidal and other atmospheric motions. Solar ultraviolet radiation accounts for most of the heating (70 – 80 %) and has a close association with the phase of the solar cycle. Auroral zone currents and particle deposition account for another 15 – 25 % of the heating. They are generally thought to vary in concert with the solar cycle, but there is some evidence of a lagging effect due to the influence of high speed solar wind streams which occur in the declining phase of the solar cycle. [*Chun et al.*, *JGR*, 1999].

By comparing model output of solar UV heating with observations from polar orbiting satellites and proxy estimates of Joule heating from ground magnetometers observations, we assess the contribution to the global scale heating directly associated with solar activity. We will provide a comparison with a small subset of events ($\sim$ 50 days) for which more detailed estimates of Joule and particle heating are available. Further, using a database of coronal mass ejections, high speed streams and slow solar wind flow [*Richardson et al.*, submitted to *JGR*, 2000] we will also assess the effectiveness of these features in contributing to and enhancing auroral zone heating over the course of the solar cycle.

S18-10

INFLUENCE OF COSMIC RAYS ON THE ATMOSPHERIC PROCESSES

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Processes in the Earth's atmosphere, in which fluxes of cosmic rays play important role, are considered. The following effects are analyzed: ionization of air, ion balance equation in the atmosphere, global electric current, electricity and lightning production in thunderclouds, influence of charged particle fluxes on global cloud coverage and precipitation. The question on the role of cosmic ray fluxes in global warming process is discussed. In the analysis the long-term measurements of cosmic ray fluxes in the atmosphere from the ground level up to 30 – 35 km are used.

S18-11

THE EFFECT OF VARIATIONS IN GALACTIC AND SOLAR COSMIC RAYS ON THE EARTH'S WEATHER

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Daily data of pressure, temperature, and wind observations at Antarctic station Vostok in 1981 – 1991 have been analyzed in regard to the cosmic rays variations. Case study and statistical treatment of the data provide the following results. Beginning of the Forbush decrease of galactic cosmic rays is followed within one day by significant warming of atmosphere (about 10 degrees) at altitudes $h < 6 - 7$ km in the near-pole region. Duration of warming is about one day, then the atmosphere quickly recovered to previous temperature conditions. The Forbush decrease is accompanied by reduction of atmospheric pressure at all altitudes below 20 km, the magnitude of reduction being maximum at higher altitudes. Reduction of atmospheric pressure can develop synchronously with the Forbush decrease or can delay for $1 - 6$ days depending on the preceding meteorological trends, intensity of the Forbush decrease, and occurrence of the solar proton spikes. Spikes of solar cosmic rays affect the increase of atmospheric pressure at altitudes $10 - 15$ km within $0 - 2$ days. The troposphere warming and reduction of the pressure in low stratosphere and troposphere is followed within $0 - 6$ days by rotation of the wind over Vostok from predominantly West direction to the South-East one. Conclusion is made that fluctuations of the solar and galactic cosmic rays crucially influence temperature and pressure regime above the Antarctic plateau and can dramatically change the wind system above Antarctica. In the northern polar region, where variability of atmospheric parameters is much higher than that in the southern region, effects of short-term changes in the solar activity on atmosphere have been revealed by statistic methods.

S18-12

COSMIC RAY VARIATIONS EFFECT ON HIGH-LATITUDE TROPOSPHERE: OBSERVATIONS AND MODEL

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Analysis of an experimental data has shown that both the bursts of the solar cosmic rays (SCR) and Forbush-decreases of the galactic cosmic rays (GCR) have a great effect on the temperature, pressure, and circulation of the high-latitude troposphere (Greenland, North-Atlantic islands, Denmark, Finland, and northern Russia). The character of the atmosphere parameters variations depends on latitude, longitude, and synoptic zone. Also, for some stations the character of these variations both for the bursts of SCR and for Forbush-decreases are same.

The results of some previous works have shown great changes of atmospheric transparency for a visible solar radiation (probably due to variations of a cloud cover, aerosols, and/or NO_X concentration) associated with changes of SCR and GCR fluxes. Based on this hypothesis, a radiative model has been used to simulate these variations of the atmosphere parameters.

S18-13

MODEL OF THE INCREASING OF THE QUASIBIENNIAL SOLAR ULTRAVIOLET EFFECTS UPON THE STRATOSPHERE AND LOWER ATMOSPHERE

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The QBO variation of activity of the Sun influences intensity of cosmic rays which are incoming in atmosphere of the Earth and, therefore, on a kinetics an ion-molecular reactions in atmosphere. The local chemical structure of atmosphere especially concentration of an ozone is changed owing to this variability. This fact influences absorbability of atmosphere in ultra-violet range of radiation of the Sun. Therefore, temperature of the lower stratosphere is vary on value of few tens degrees on Celsius and QBO variation of heating of the lower stratosphere is produced. This irregularity begins to influence dynamic processes of the lower atmosphere: the vertical motions of atmosphere arise originally at stable changes of temperature of a stratosphere, and then they pass in current motions in a stratosphere under Coriolis force. These currents are transmitted in the lower atmosphere under a turbulent diffusion, and they influence some parameters of dynamics of atmosphere. The calculations show, that a time range, which expended for current from a stratosphere to atmosphere near the Earth's surface, is compare with quasi-two-years period of solar activity. Thus, this process provides temporary filter and results that the QBO-effects, which observed in atmosphere, have the greater amplitude, than effects of an 11-year's cycles of solar activity.

S18-P01

THE ARCTIC SEA ICE EXTENT AS A FUNCTION OF SOLAR VARIABILITY

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It is a well established fact that the polar sea ice extent is an important parameter of the world climatic system. An active discussion of possible diminishing of the Arctic sea ice extent (assuming its disastrous climatic consequences) is going on now. It is evident that all realistic predictions of this parameter must be based on knowledge of the main physical processes determining the sea ice cover dynamics. Among them the factors of the solar variability influence have not yet been understood properly. In this paper we study dependence of the sea ice extent in different parts of Arctica on the various kinds of solar variability. Besides the standard solar activity index-sunspot number (SSN) we used in this study another source of the solar energy-the solar wind dynamic pressure. We studied also relation between the Arctic sea ice extent and level of geomagnetic activity expressed as "*aa*" index, which is strongly connected with the solar activity level. A special method of statistical study was used in our analysis. The main results of this study are the following: 1) the sea ice extent in various parts of Arctica respond diversely to the all kinds of solar activity; 2) the solar wind energy plays a notable role in processes of sea ice cover formation (in some parts of Arctica); 3) the Arctic sea ice extent depends on geomagnetic activity represented as "*aa*" index in the same way as on solar activity level expressed by SSN. The possible explanations of the obtained results are given.

S18-P02

THE INFLUENCE OF SOLAR VARIABILITY ON THE ATMOSPHERIC CIRCULATION IN THE BERLIN CLIMATE MIDDLE ATMOSPHERE MODEL (CMAM)

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11-year variations in solar irradiance have been shown to impact the mesosphere and upper stratosphere by changing the radiation budget of the atmosphere. Associated temperature changes may lead to changes in atmospheric circulation. Recent simulations with Climate Middle Atmosphere Models discussed the possibility of an indirect dynamical response of the lower atmosphere to the radiative forcing of the upper atmosphere, but details of the simulations are still controversial.

First results of simulations with the Berlin CMAM under solar maximum and solar minimum conditions will be presented. The prescribed changes in spectral solar irradiance and ozone were the same as defined for the GRIPS solar forcing initiative thus enabling the intercomparison of the model results with similar studies.

The model's thermal and dynamical response to the solar forcing will be shown and compared with results from observational analyses (FUB and NCEP). Additionally, a comparison of the model results with former QBO experiments will be presented.

S18-P03

SEVERE MAGNETIC STORMS AND SURFACE PRESSURE ASSOCIATIONS AT HIGH LATITUDE

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We have made an attempt to find the correlation between solar atmosphere and earth's physical parameters such as H (earth's magnetic field) and P (surface pressure). The effect of geomagnetic storms has also been studied in the present work. The enhancement in the solar wind is followed by a sudden increase in Dst index. Correspondingly (increase in −ive value) of H at Mascow station shows sharp change during geomagnetic storm period. We have not found and effect of geomagnetic storm on daily average value of surface pressure observed at Mascow station. The surface pressure shows +ive CC (+0.72) with sunspot number at the timelag of −10 days. Similar feature also has been obtained between earth's magnetic field and sunspot number. The surface pressure and solar wind shows +ive CC (+0.48) at the time lag of +10 days. Similarly, H and solar wind shows maximum +ive CC (+0.50) at the time lag of +10 days. The sunspot number and solar wind shows maximum correlation with earth's atmospheric parameters (surface pressure and earth's magnetic field) at the opposite time lag of about 10 days. This shows that the physical mechanism responsible for weather changes are different for sporadic sunspot activity and recurrent geomagnetic activity.

S18-P04

SOLAR AND TROPOSPHERIC VARIABILITY EFFECTS ON SCHUMANN RESONANCES

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Schumann resonances (SR) are extremely low frequency (ELF) electromagnetic waves produced by lightning discharges and trapped in the Earth-ionosphere waveguide. The SR parameters observed at a single station are controlled by the global lightning activity, which in turn, is related to different climate variables such as surface air temperature, vertical air convection, upper tropospheric water vapour concentration, etc.. SR frequencies and amplitudes have been recorded continuously for the vertical electric component at the Nagycenk Observatory, Hungary since May 1993. The annual and semiannual variations of SR intensity (*Satori and Zieger*, *JGR*, 1996) and the El Nino related variation of SR frequency have been reported and discussed recently (*Satori and Zieger*, *GRL*, 1999). In the present study, we identify periodicities in SR amplitudes and frequencies in the period range from a few days to half a year and discuss their possible origin. The observed intensity and frequency of Schumann resonances depend not only on the source intensity and the source-observer distance but also on the physical parameters of the Earth-ionosphere waveguide. Dynamic spectra of daily SR amplitudes and frequencies were computed for the first three modes and were compared with dynamic spectra of solar wind speed and geomagnetic indices such as Kp and Dst. Several periodicities were identified including 108 days, 73 days, 47 days, 27 days, 20 days, 13.5 days and $9-10$ days. The most significant correlation between SR parameters and solar wind speed (or geomagnetic activity) was found at the period of 13.5 days (half a solar rotation period). This implies a solar influence on the upper boundary of the Earth-ionosphere waveguide, *i.e.* the ionospheric D region, most probably through energetic particles (MeV protons and electrons). We investigate the role of energetic particles in the solar rotation modulation of SR parameters using energetic particle data from different satellites.

S18-P05

THE ATMOSPHERIC NITROGEN DIOXIDE (NO_2) VARIATION AND GALACTIC COSMIC RAYS

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Effect of the long term-variation of galactic cosmic rays (GCR) and solar activity on the trace gas, such as NO_2 was investigated. There was analyzed the annual and seasonal variation of the trace gas. Also is considered the distribution of NO_2 in the lower atmosphere at the middle latitudes. The results of NO_2 cyclic variation investigations content in the atmosphere are presented.

S18-P06

MAGNETIC-SOLAR-CYCLE-INDUCED RAINFALL VARIATIONS IN BRAZIL

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For a long time it is known about influence of 11- and 22-year solar cycles on the Earth's weather. In some regions of the Earth the cycles (anti-) correlate, for example, with the variation of rainfall level. A mechanism causing this correlation is still not discovered. We suggest actualized data (up to 2000) of rainfall variations in three meteorological stations (Fortaleza: 3,76S, 38,5W; Campinas: 22,54, 47,05W; Pelotas: 31,75S, 52,35W) from 1849 up to 1999 that cover practically whole latitude range of Brazil. Periodic analysis of annual rainfall level in Pelotas and in Fortaleza shows pronounced 22-year periodicity existing about 100 - 150 years with great variation amplitude of about 200 - 400 cross correlation analysis shows the rainfall variation correlate/anticorrelate with 22-year solar magnetic cycle with the correlation coefficient of about 80. In observational period a phase of correlation changed one time from anticorrelation to correlation in Pelotas and from correlation to anticorrelation in Fortaleza during a relatively short period of 1 year. The year of the phase changing coincides with a year of changing of solar magnetic field polarity and revealed first in higher latitudes of Pelotas (1927 - 1928) and then, appeared in Fortaleza 22 years after (in 1948 - 1949). A short term (daily) correlation of rainfall level with solar flare particle events, (exactly with GLE events), Forbush decreases and geomagnetic storms during 50 - 70 years of observations was searched minding that charged particles of solar flares, cosmic rays or magnetospheric origin could change transparency of the atmosphere. The results will be communicated. The study is important both as scientific instrument for solution of S-T connection problem and for long term forecasting of the weather in South American region.

S18-P07

ON RELATIONSHIP BETWEEN SOLAR VARIABILITY AND INTENSITY OF CYCLONES OVER EASTERN EUROPE

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At present, a considerable number of solar variability effects on the troposphere are established from changes in the vorticity area index with respect to sector boundaries of the interplanetary magnetic field, IMF. Nevertheless, processes on the Sun cause a complex of interrelated changes in the system Sun Earth, therefore it is difficult to select the most important of them using only one indicator of solar variability. To proceed from this, by applying the method of superposed epoch analysis, we successively compare the tropospheric data with solar activity indices, IMF and other parameters of the solar wind, and geomagnetic disturbances. In order to estimate tropospheric processes, there was used a new weather index, Iw, giving the complex estimate of cloudiness and atmospheric precipitation in terms of numbers: its value changes from 0 to 5 when there are changes from clear weather to that with heavy precipitation. The Iw may be considered as an indicator of intensity of cyclones. The Iw was calculated from the data of the Kharkiv hydrometeorology center. The geomagnetic disturbances were found to be the most possible cause of tropospheric processes. The effect was recorded even for moderate geomagnetic storms ($Ap \sim 20-30$). For each of the geomagnetic storms, two Iw responses are observed: the rapid (as a rule, for a day when a geomagnetic storm commences) and the slow (on the average, in 6 days). As to its time delay, the latter agrees with the data from [1] and may be explained by changes in a type of the atmospheric circulation [2]. Causes of the rapid response require additional investigations.

1. *Loginov, W., et al., The works of Sci. Res. Institute of Hydrometeor. Invest.*, **37**, 97–112, 1978 (in Russian).
2. *Bucha, V., Ann. Geophys.*, **6**, 513–524, 1988.

S18-P08

VARIATIONS OF SOLAR ENERGETIC PARTICLE AND EUV FLUXES GOVERN THE CLIMATIC CHANGES

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Sun is a dominant source of broadband electromagnetic wave radiations and energetic particle emissions. In addition to this dominant source, the earth's atmosphere is exposed to omnidirectional cosmic ray flux. The galactic cosmic ray flux and the solar cosmic ray flux are capable of penetrating through the earth's atmosphere and are known to ionize the earth's lowermost atmosphere. The variations in the earth's lower most atmosphere and the resulting climatic variations are caused by the combined effect of galactic and solar cosmic ray fluxes in addition to solar UV radiations. Climatic parameters in the Imndian sector over the last solar cycle has been compiled and variational features are compared with the incidence of galactic and solar cosmic ray fluxes in addition to EUV variations. It is clearly shown that the sun is a dominant controller of the earth's climatic variations. The cosmic ray fluxes are seen to produce ionization effects at lower altitudes which is known to generate localized storm at the surface level. The prediction of these effects, their control and safety measures are becoming matter of great concern. Some of these details particularly in the Indian continent are discussed in detail.

S18-P09

SEVERE MAGNETIC STORM SIGNATURE IN LOWER ATMOSPHERE AT MAGNETIC EQUATOR

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We have made an attempt to study the impact of geomagnetic storm on physical parameters such as earth's magnetic field, surface pressure variation, mesospheric electron density variation. The data utilised in the present work is for September 1999, which is the space weather month. Each data points studied in the present work corresponds to the 24 hours average. Therefore diurnal variation has been minimised. A severe magnetic storm has occured on 23rd September which is very well reflected in the enhancement of earth's magnetic field. A moderate storm has also occured on 12 September, caused enhancement in the mesospheric electron density. The mesospheric electron density has been measured from 84 to 98 km altitude by using Partial Reflection Radar. The surface pressure variation observed by microbarograph at magnetic equator does shows the effect of severe geomagnetic storm. The geomagnetic storm causes large variation in surface pressure after 23rd September 1999. We have also studied the correlation coefficient between earth's and solar atmosphere. The sunspot number and earth's magnetic field as well as surface pressure shows maximum correlation (+0.72) at the time lag of −11 days. The solar wind and earth's parameter shows maximum correlation (+0.50) with time lag of +10 days. The *Dst* index and surface pressure shows −ive correlation at the magnetic equator. This shows that there are two kind of mechanism affecting the earth's atmosphere. First one is sunspot sporadic arelated activity and other one is recurrent geomagnetic activity. The spectral analysis of these data has been performed and it is found that quasi 3-day wave is present in troposphere, mesosphere and lower thermosphereic region. The detailed result will be presented and discussed.

S18-P10

SOLAR AND GEOMAGNETIC CYCLES AS REFLECTION OF SOLAR SYSTEM DYNAMICS

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Spectrum of the of geomagnetic variations on the Earth (D component, 1600 – 1998 yr.) was obtained via MGM method. MGM was used to calculate a spectrum in the annual Wolf sunspot numbers W for the time from 1700 to 1999 yr. MGM is capable of making a self-consistent selection of trends from a data set and singling out harmonics with varying phase and amplitude. Deterministic part of both spectra is discussed (confidence limit > 98 %). All non-stationary harmonics in the spectra demonstrate a non-linear mechanism of their generation; their periods and other characteristics are derived. The powerest trend is described by polynomial in W data. The powerest longest harmonic at $T = 720$ yr. in D spectrum has the minima at $t \sim 1850$ yr. The trend in W spectrum has a minima at $t \sim 1870$ yr. Coincidence (with accuracy of error bars) of the extrema indicates to outstanding events both in solar and the Earth's magnetic dynamo for the studied interval. The sharp increase of discrepancies in the Moon's longitudes are observed during this period. Rotation velocity of the Earth was increasing too (to 1870 yr.). Thus, the long-term part of the solar and geomagnetic changes is connected with regularities in the dynamics of the solar system. It is shown that tidal forces of the planets can cause common resonance periods in these spectra. Periods of the planet tide forces are detected in both spectra. Kepler's symmetric component of tide forces is presented by overtones only external planets. The periods of asymmetric component of perturbed tide forces are brightly presented in the spectra. A possible physical mechanism is suggested, showing a possibility of generation of large magnetic fields caused by a small changes of a dissipative parameter of a dynamo system. It is shown that the cause of these small oscillations of dissipative parameters can be asymmetric perturbed tide forces of the planets.

S18-P11

COSMIC RAYS IN THE EARTH'S ATMOSPHERE: DIRECT AND INVERSE PROBLEMS

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DIRECT PROBLEM: The direct problem of influence of meteorological processes on cosmic ray atmospheric cascade, intensity and contents (the problem of cosmic ray meteorological effects) is one of crucial in cosmic ray research. We consider here the development and present status of theoretical and experimental investigations of cosmic ray meteorological effects for continue observations on many cosmic ray observatories by neutron monitors and muon telescopes.

INVERSE PROBLEM: Cosmic rays in the atmosphere produce ionization which depends from altitude and cut-off rigidity, and changed in time in dependence of the level of solar activity, interplanetary shock waves (Forbush-decreases), and in periods of great flare energetic particle events. Nuclear interactions of cosmic rays with air atoms produce a lot of cosmogenic nuclides. Cosmic rays influence also on chemical reactions in the atmosphere. Additional ionization and chemical reactions produced by cosmic rays may influence on radio-wave propagation (especially in the low ionosphere), on ozone layer and clouds formation, on long-term global change of climate.

S18-P12

STATISTICAL CHARACTERISTICS OF THUNDERSTORM RADIATION AND SOLAR ACTIVITY

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The VHF range spectrum analysis of radiation caused by durable thunderstorms (t > 1h) is performed. Thunderstorms were observed at middle latitude ($\phi = 50$ grad), and one auroral thunderstorm was registered (t > 7h, $\phi = 72$ grad). It was found that radio noise caused by thunderstorm may be of three types: 1. Impulse like emission from thunderstorm discharge $< 10^{-20}$ W/m^2 Hz; 2. Continuous background radiation of thunderstorm kernel $\sim 10^{-22}$ W/m^2 Hz; 3. Continuous radioemission of ionosphere stimulated by thunderstorm-ionosphere discharge $\sim 10^{-22} - 10^{-23}$ W/m^2 Hz. Typically thunderstorm has three characteristic periods: 1. Thunderstorm origin; 2. Maximum of thunderstorm kernel evolution; 3. Thunderstorm fading. Thunderstorms with t $\sim$ 1h have all periods approximately of the same duration. More durable thunderstorms have more durable second period. Radiation is modulated by quasiperiodic fluctuations of number of factors: thunderstorm background emission, number of discharges and upper envelope curve of discharges. These factors have distinct statistical properties. Fluctuation spectrum of origin thunderstorm phase and fading phase are quite wide, periods are $\sim 3 - 20$ min. Maximum phase of thunderstorm evolution is characterized by narrowing of fluctuation spectrum down to 10 ± 2 min. Usually spectrum has only one maximum with duration $\sim$10 min. According to known literature the similar statistical characteristic has radiation at low latitude. Such a behaviour indicates that external factors have influence on thunderstorm generator. One of the probable factors is modulation of thunderstorm generator back way current by solar activity (most likely by its 5 min oscillations) in fair weather region. So, the control of thunderstorm generators may be performed by solar activity using second harmonic.

S18-P13

SEISMOACTIVE REGION OF KURILES AND JAPAN: INFLUENCE OF COSMIC FACTORS. EXPERIMENTAL DATA AND THEORETICAL ESTIMATES

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Variations of the frequency of strong and weak, deep and nondeep earthquakes for the long time period associated with changes of solar activity, galactic cosmic rays fluxes, Kp-index of geomagnetic activity and atmospheric pressure were studied. The results of this research allow us to make some conclusions about connection between lavel of solar activity and seismisity. The theoretical estimates of this influence and the comparison of these estimates with experimental data were obtained.

S18-P14

A COMPARATIVE STUDY OF SPORADIC E-LAYER AT KARACHI DURING THE SOLAR MAXIMUM (1989 – 90) AND SOLAR MINIMUM (1996 – 97)

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A careful study of quarter hourly ionograms at Karachi (24.95° N, 67.14° E, near the crest of equatorial anomaly region) for the Solar Maximum (1989 – 90) and Solar Minimum (1996 – 97) has shown that there exists a negative correlation in frequency of the occurrence of Es-layers with the solar activity. This trend is found to be opposite to the trend reported by the previous investigators regarding the occurrence of Es at mid-latitudes. An in-depth study of blanketing sporadic E (Es) layer at Karachi reveals: i) Though the Es-layer at Karachi is found to be a day and nighttime phenomenon, it frequently occurs on daytime at the two levels of solar activity. The most likely time of its occurrence in daytime is before noon (0830 – 1030 hrs PST) at Solar Maximum (1989 – 90), whereas after noon (1200 – 1400 hrs PST) at Solar Minimum (1996 – 97). In nighttime it occurs more frequently around mid-night (2200 – 0200 hrs PST) at Solar Maximum and Solar Minimum. Duration of an event of Es-layer has been observed for 30 – 90 minutes in the most cases during the two levels of solar activity. ii) Occurrence of Es at Karachi shows Maxima in Summer and Minima in Winter at Solar Maximum. iii) The specific cases of blanketing Es-layer producing total blanketing of the overlying Fl and F2 layer, hence causing the failures of HF communication, are observed to be greater in all seasons at Solar Maximum than at Solar Minimum. During both the Solar conditions, it occurs minimally in Winter and maximally in Summer.

S18-P15

LOW CLOUD PROPERTIES INFLUENCED BY COSMIC RAYS

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A correlation between total cloud cover and the flux of cosmic rays incident on the atmosphere has been observed during the last solar cycle. The flux of Earth bound cosmic rays are modulated by the state of the heliosphere, while clouds play an important role in the Earth's radiation budget through trapping outgoing- and reflecting incoming radiation. From these early studies it was not possible to ascertain which cloud types were influenced. Here it will be shown that the influence of solar variability is strongest in low clouds (< 3 km). These are liquid water clouds, which points to a microphysical mechanism involving enhanced aerosol formation. If confirmed it suggests that the average state of the Heliosphere is important for climate on Earth. The estimated response in low clouds due to a doubling of solar activity over the last 100 years is a 1.4 W/m^2 warming.

S19-01

HIGH LATITUDE HF INDUCED PLASMA TURBULENCE

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Incoherent scatter radar (ISR) is an ideal diagnostic tool for use in investigations of HF-pump-induced Langmuir turbulence in space. Since the first such experiments at Arecibo in the early 1970s, ISR has been the principle diagnostic for such studies. At high latitudes EISCAT, which operates high resolution incoherent scatter radars at 224 and 931 MHz and an HF transmitter possessing more than 1 GW in effective radiated power, is the only facility where such experiments may be performed. EISCAT is located in northern Scandinavia where the geomagnetic field lines are offset from vertical by just 13 degrees, making possible a wide variety of interesting active ionospheric radio propagation, wave interaction, and HF Langmuir turbulence experiments. Significant improvements have recently been made in theoretical concepts, computer models, and experimental techniques designed to aid in improving our understanding of Langmuir turbulence. In particular, progress has been achieved at EISCAT towards scientific agreement on a set of phenomena that are universally observed during both high and low latitude ionospheric Langmuir turbulence experiments. Other experiments have made use of the geomagnetic geometry as a tool to create and study HF-induced Langmuir turbulence both below the bottomside critical level and in the topside ionosphere. Results of these and related experiments will be presented and directions for the future will be discussed.

S19-02

SIMULATION STUDY ON UPPER HYBRID AND ELECTROMAGNETIC EMISSIONS IN IONOSPHERIC RADIO MODIFICATION EXPERIMENTS

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Stimulated electromagnetic emissions (SEE) are nonlinear plasma phenomena observed in the ionospheric modification experiments by means of high-power HF radio waves. The SEE spectrum has a rich structure extending around the pump frequency. The experiments found a close connection between the SEE features and small-scale magnetic field-aligned irregularities thermally generated in the upper hybrid resonance region of the pump wave. Some theoretical models for explaining the formation of the irregularities and the excitation of the secondary electromagnetic emissions are based on ideas of trapped and driven upper hybrid oscillations. The theories suggest the pre-existing irregularity leads to generation of the upper hybrid waves which are trapped in density depletions of the irregularity, and furthermore it causes transformation of the electrostatic waves to the electromagnetic ones due to wave-wave interactions.

We performed particle-in-cell (PIC) simulations assuming the ionosperic modification experiments to describe details of the interaction processes. In the simulation model, an obliquely propagating pump wave is continuously injected into the region where a small-scale field-aligned irregularity exists. The simulation results demonstrate the emissions of UH wave, low-frequency and HF electromagnetic waves in the inhomogeneous plasma. We discuss on conditions of the most interesting feature in the SEE spectrum, broad upshifted maximum (BUM), according to proposed theories of parametric four-wave interaction.

S19-03

TRIGGERING OF LOCAL SUBSTORM ACTIVATIONS INDUCED BY THE TROMSØ HEATING FACILITY

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Experimental results from Tromsø HF pumping experiments in the nightside auroral ionosphere are reported. A bistatic HF Doppler radio scattering setup has been used in conjunction with the EISCAT UHF radar, the DASI digital all-sky imager, the IMAGE magnetometer network, the Tromsø dynasonde and IMP 8, 9 satellites to find the evidence that powerful HF radio waves produce the modification of the ionosphere-magnetosphere coupling which can lead to a local substorm activation. Summarising multi-instrument observations one can distinguish the following peculiarities related to this activation: modification of the auroral arc and its break-up above Tromsø; local changes of currents in the vicinity of Tromsø; increase of the electron temperatures and ion velocities at altitudes above the HF pump reflection level; distinctive features in dynamic HF radio scatter Doppler spectra; pump-induced electron precipitation; substorm activation exactly above Tromsø. The possible mechanisms of the local substorm activation through the enhancment of field-alighned currents and excitation of the turbulent boundary layer inside an ionospheric Alfvén resonator in the selected magnetic flux tube footprinted on the heater-enhanced conductivity region are discussed. The obtained results prove the active role of the auroral ionosphere in a substorm process and provide a strong evidence that the location and timing of the auroral activation was related to the HF pumping experiment, but its energy source remains the interaction between the solar wind and the magnetosphere.

S19-04

THE STUDIES OF THE IRREGULAR STRUCTURE OF THE LOWER IONOSPHERE BY THE API TECHNIQUE

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The studies of the irregular structure of the lower ionosphere (the E- and D-regions) have been carried out in 1999 (August, 10 – 12) near Nizhny Novgorod (56.15N, 44.3E) using API technique. As is known, the artificial periodic inhomogeneities (API) are formed in the field of a powerful standing radio wave as a result of the interference of waves incident and reflected from the ionosphere. Experiment was carried out using SURA heating facility at the frequency of 5.69 MHz X-mode. The power transmitter was turned on for three second three times per minute. Amplitudes and times of relaxation of signals back scattered by the API were measured at the same frequency when the power transmitter was turn off. The height step of the sample data was 0.7 km and the repetition frequency of probing pulses was 50 Hz. Range-time-amplitude plots of API echoes were obtained at height range from 60 km (D-region) up to the bottom of the F2-layer. The existence of the ionospheric irregularities and sporadic E-layers which have been observed permanently. The sporadic layers between 80 and 95 km existed during some hours and the irregular structure of these layers was visible.The sporadic layers as lower as above the E-layer maximum were observed and division of the E-layer maximum on two parts took place also.The additional layers in the interlayer E-F valley at the height $\sim$ 140 km were seen during 20 – 30 minutes. Sometimes descent down to the E-layer maximum was observed. The appearance of the additional layers in the valley was noted in 1998 by *Bakhmet'eva et al.* (*Radio Sci.*, **33**, 583–595). The work was supported by RFBR under Grants N 99-05-64464 and N 00-05-64695.

S19-05

ACTIVE EXPERIMENTS WITH HIGH-SPEED INJECTIONS FROM SPACE

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High speed injection of neutrals and ions into the upper atmosphere permits the study of processes that occur in nature. Several recent experiments involving the Space Shuttle and sounding rockets have provided new insight into the physics of high-speed ion interactions. The Shuttle Ionospheric Modification with Pulsed Localized Exhaust (SIMPLEX) used ground based incoherent scatter radars at Arecibo, Puerto Rico; Jicamara, Peru; and Kwajalein, Marshall Islands to detect non-equilibrium ion distributions in the Space Shuttle exhaust. Dedicated firings of the orbital maneuver subsystem (OMS) engines injected water vapor molecules with kinetic energies of 10 eV. Charge exchange with the ambient atomic oxygen ion produced molecular ion beams moving 10 times the ion sound speed. The relaxation of these beams was detected with incoherent scatter radars and the presence of turbulence from kinetic instabilities was inferred. The ion-line spectra from the radar was similar to that seen in disturbed auroral ionosphere. These experiments were conducted between 1997 and 1999 on Shuttle flights STS-86 and STS-93. During 1997, the FLUXUS I and II experiments released plasma jets parallel to the magnetic field near 150-km altitude. These jets were observed optically with the MSX satellite and with ground sensors. A follow-on experiment called APEX North Star was conducted in early 1999 involving two explosive payloads and two diagnostic payloads. The diagnostics included both plasma sensors (Langmuir Probe, electric field sensor, plasma wave receiver) as well as high-speed optical sensors. The measurements provided the full spectrum of plasma kinetic effects initiated by the injections.

S19-06

BEAM-PLASMA EFFECTS OF ARTIFICIAL ORBITAL INJECTION (OVERVIEW OF APEX MISSION RESULTS)

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The main results of Active Plasma EXperiments (project APEX) are presented. For the first time an opportunity of injection of an electron beam was shown under limited conditions to neutralise a charging of spacecraft by environmental plasma. The supervision are executed in a wide range magnetosphere conditions: from equatorial up to high latitude zones, including magnetic force tube extending on many radiuses of the Earth. These supervision show that the modulated electron beam can be used as a effective radiating aerial. For the first time VLF emission of a modulated electronic beam is registered at subsattelite on distances of hundreds km. Series of coordinated active experiments above groundbased radio heating facilities were conducted. An opportunity for tunnelling effect was demonstrated. Researches of Alfvén critical ionisation velocity (CIV) phenomena during a neutral xenon gas injection are executed.Passive measurements of parameters of a plasma in auroral and equatorial zones in a range of heights of 450 – 3000 km were conducted.

S19-07

STABILITY OF ELECTRODYNAMIC TETHERS

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Electrodynamic tethers are at present being investigated especially in relation to two applications. The first one is that of obtaining propulsion and the second, important in relation to the problem of accumulation of debris in the near Earth environment, that of using tethers to deorbit LEO objects. For both applications, the relative importance of electrodynamic forces with respect to gravity gradient forces can be much greater than for systems, like TSS, which have already being flown.

One main problem, concerning the feasibility of these applications is that of the dynamic stability of the system and the ways to control it when necessary. There are in fact indications, from extensive numerical simulations, that the system may go unstable but the numerical simulations themselves are not capable of illustrating the physical mechanism of the intability and associate that with a critical parameter.

In this paper we present initial results of an analytical approach to the problem of stabilty of electrodynamic tethers in the framework of a model where the tether current is assumed to be given with a plausible frequency content.We indeed find possible instabilities of the lateral modes of the tether and obtain thresholds as a function of current. More significantly, the treatment leads to the determination of a dimensionless parameter (a function of the current and the parameters of the given tether system) which controls the tether stability.

S19-08

NUMERICAL SIMULATIONS OF ELECTROMAGNETIC INTERACTION BETWEEN ANTENNA AND SPACE PLASMA

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We studied the electromagnetic interactions between antenna and space plasma by performing EM-PIC (Particle-In-Cell) simulations. We particularly focused on the field and plasma environment of the sheath region formed around antenna. Previous theoretical studies found new modes of electromagnetic wave called sheath waves which propagate along the plasma-metal interface on the assumption that the sheath region is vacuum. To examine the property of the sheath waves, we performed PIC simulations with a two-dimensional model which includes a metal surface of antenna immersed in magnetized background plasma. Due to the difference of thermal velocity between electrons and ions, an ion sheath is created near the antenna surface. We basically could confirm the sheath waves propagating along the metal-plasma interface at the frequencies lower than those of normal wave modes for a uniform plasma. The dispersion relation of the sheath waves is modified in the simulations because the electron density gradually changes at the transition region from the background plasma to the sheath while a sharp boundary is assumed in the theory. We also investigated an active antenna case in which we added high power RF electric field to the antenna. The nonlinear effects to the sheath formation and associated antenna charging were examined by PIC simulations.

S19-09

OF CURRENT INTEREST: PROBES AND ELECTRODES IN SPACE MAGNETOPLASMAS

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Recent space experiments, including CHARGE-2, SPEAR I, and especially TSS-1 and TSS-1R, have generated increased efforts to improve current-collection theories for large, positively charged objects in space. In all of these experiments, electron collection exceeded substantially that predicted by the theory of Parker and *Murphy* (1967) for spherical probes in collisionless magnetoplasmas. In all three experiments, breaking of rotational symmetry about the magnetic-field direction was invoked as a cause of this excess current. In CHARGE-2, electron-beam emission was involved, but symmetry-breaking also occurred because of asymmetry of the shape of the spacecraft. In SPEAR I, it was caused by the presence of the oppositely charged rocket body which carried the spacecraft's large electron-collecting spherical probe. In the case of TSS-1 and TSS-1R, orbital speed large compared with the ion thermal speed produced such symmetry-breaking, even though this speed was small compared with the electron thermal speed. It is widely believed that time-averaged current collection may also be increased by effects of plasma turbulence. We review the available evidence for and against this contention, and we also review older steady-state theories and recent developments in theory for electron collection from the space plasma environment.

S19-10

FLOATING POTENTIALS OF CONDUCTORS IN SPACECRAFT DIELECTRICS

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Electrostatic charging continues to be a threat to high altitude spacecraft. On satellites, conductors that are electrically "floating" represent a special danger, which explains why designers take such pains to provide conductors with DC paths to the satellite-frame "ground". Measuring the potentials of an array of conducting probes embedded at different depths in a variety of different but relevant dielectrics is clearly a technique that could lead to a useful spacecraft monitor device to warn of a worst-case threat, as well as providing needed insight both into the physics of energetic-electron charging and into better principles of spacecraft electrical design.

A 12-channel monitor device based on the above concepts has been built, and then tested in the laboratory under high vacuum. The electron source is a Strontium-90 radioisotope approximately representing a moderate magnetic storm at geosynchronous orbit, and its use has enabled continuous long-term tests up to $3-4$ weeks in duration. The results of these tests include the observation of 1) potential-growth time constants at different depths with potentials stabilizing as high as 12 kV negative, 2) discharge events, 3) ion neutralization as a function of depth, and 4) comparative properties of different dielectric materials.

To predict such effects, numerical modeling of field-enhanced conduction and charge redistribution in irradiated dielectrics has been done using Monte Carlo and finite-element techniques. The computation is essentially one-dimensional and the dielectric can be multilayered and have metal inserts acting as probes. Such computations have produced results in agreement with experimental data and have shown that, with proper calibration, conducting probes inserted in dielectrics can be used to characterize the charging/discharging state. Further, the computations show that it is necessary to take into account the interactions with external circuits, especially those involving the internal and external capacitances of the probe conductors.

S19-11

COMPUTATION OF CURRENT TO A MOVING BARE TETHER

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An electrodynamic bare tether has been considered as an alternative method of propulsion without expenditure of propellant. The object of the work reported here is the development of a numerical method, Particle-In-Cell method, for the calculation of electron current to a positive bare tether moving at orbital velocity in the ionosphere, *i.e.* in a flowing magnetized plasma under Maxwellian collisionless conditions. The code uses the quasi-neutrality condition to solve for the local potential at points in the plasma which coincide with the computational outside boundary. Given the boundary conditions, Poisson equation is solved in such a way that the presheath region can be captured in the computation. Electrons are assumed to have a Maxwellian distribution at the boundary due to their high mobility, whereas ions are assumed so only in the far upstream region and are also assumed to only decelerate one-dimensionally due to their large mass. The results indicate a stable convergence, and clearly represents a presheath region. Collected currents turn out to be more than that predicted by the Orbital Motion Limit (OML) theory. As a possible cause of the enhanced current collection, particle-field interaction, which may be responsible for the plasma heating, is observed.

S19-12

FIRST RESULTS FROM THE RADIO PLASMA IMAGER ON THE IMAGE MISSION

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The Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) mission was successfully launched on March 25, 2000. IMAGE was placed into a polar orbit with apogee of about 7 Earth radii (R_E) and inclination of about 45 degrees. The Radio Plasma Imager (RPI) on IMAGE is a radio sounder designed to sweep from 3 kHz to 3 MHz. Radio plasma imaging uses total reflection of electromagnetic waves from plasmas whose plasma frequencies equal the radio sounding frequency and whose electron density gradients are parallel to the wave normals. The RPI has two orthogonal 500-m long dipole antennas in the spin plane for transmission and reception. The spin axis antenna is a 20-m dipole for reception only. Echoes from magnetospheric boundaries and plasma regions have been received on all three orthogonal antennas, allowing the determination of the angle-of-arrival of the echoes. RPI has been operating in three active sounding modes: (1) remote sounding to probe magnetospheric boundaries, (2) local (relaxation) sounding to probe the local plasma, and (3) whistler stimulation sounding. In addition, there is a passive mode to record natural emissions, and to determine the local electron density and temperature by using a thermal noise spectroscopy technique. On the IMAGE mission, RPI is well situated to observe the structure and dynamics of a number of magnetospheric boundaries over periods of several hours during geomagnetic storms. This paper will provide an overview of the early measurements from the RPI instrument during many of its operating modes.

S19-13

PLASMA SOUNDER EXPERIMENT IN THE LOWER ALTITUDE IONOSPHERE (S310-28 ROCKET EXPERIMENT)

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The sounder experiment (SDR) was carried out onboard the S310-28 rocket which was launched on February 2, 10:30 (JST) in 1998 for the verification test of the function of instrumentation for the Lunar Radar Sounder Experiment (LRS) to be installed on the SELENE satellite. The S310-28 SDR system consists of two sets of the 14 m tip-to-tip dipole antennas and an electronics package including a high power transmitter and receiver in HF frequency range from 800 kHz to 11 MHz. Provisional data analyses showed that power transmitter radiated the designed power of about 60 watts and confirmation has been made for radar sounder function. Sounder experiments were carried out in the low altitude region of ionosphere with in the altitude range from 100 to 180 km. We found a interesting feature of the echo signals near 3 MHz returned from the bottom side F-region ionosphere, however there was no signal from the ground in this frequency range. The echoes found in the altimeter operation at around 10 MHz shows that sounder pulse propagate along the field aligned irregular structures appearing in the E-region ionosphere.

S19-14

SUMMARY OF SYMPOSIUM S19

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S19-P01

HF BISTATIC SCATTER OBSERVATIONS OF ARTIFICIAL FIELD-ALIGNED IRREGULARITIES UNDER DIFFERENT ELEVATION ANGLES OF THE TROMSØ HF HEATER ANTENNA BEAM

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Experimental studies of artificial field-aligned irregularities (AFAI) in the nightside auroral F region during quite magnetic conditions on dependence of elevation angles of the Tromsø HF heating facility are reported. They are based on observations from bistatic HF Doppler radio scatter with conjunction with the EISCAT UHF incoherent scatter radar. It was found that the most strong AFAI are generated when HF heater antenna beam was centered along magnetic field-aligned direction. It can be seen from variations of spectral power and spectral broadening of HF scattered signals under different positions of the HF heater antenna beam. A close connection between AFAI and electron temperature T_e enhancements was also observed. The distinctive feature of the modification experiment is the large T_e enhancements during heater-on periods that in $2-4$ times exceeded T_e during heater-off periods. The largest T_e enhancements observed in a wide altitude range from 200 to 600 km took place in direction parallel to the magnetic field. The most plausible mechanism that can lead to heating the electron population is the ion-acoustic instability. Another peculiarity accompanied T_e enhancements was increases of the ion temperatures and positive values of the ion velocities at the heights above 350 km that is higher the HF pump wave reflection level. Signatures observed from UHF radar data during the modification experiment under quiet magnetic conditions are indicative for the generation of HF pump-induced upward ion flows, analogous to those occurring naturally in the nightside auroral ionosphere under disturbed magnetic conditions.

S19-P02

INVESTIGATION INTO THE SPORADIC-E LAYER AND ITS ASSOCIATED PHENOMENA

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We propose to study the sporadic-E layer and its associated phenomena using a new method based on an induced 557.7 nm emission associated with the sporadic-E layer illuminated by the HF transmitter beam [1, 2] and simultaneous diagnostics of the ionosphere and thermosphere either using incoherent scatter radar or artificial periodic irregularities technique. Among those we see, for an example, investigation into phenomena associated with the Es of a patchy type when the Es is compiled from ionization clouds, which may be organized by the neutral turbulence and result in quasi periodic backscatter, which by the moment is believed to be caused by a gravity wave-modulated Es only.

S19-P03

KINETIC EFFECTS RELATED TO HF PUMPING OF THE IONOSPHERE

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Some kinetic phenomena occurring in the ionospheric F-region modified by HF powerful radio wave are discussed. Particularly, the acceleration of electrons by pump-driven HF plasma turbulence is considered in the quasilinear approximation for the pump wave frequencies close to multiple electron gyrofrequency. In this case the electrons are accelerated mainly across the magnetic field. This leads to the formation of the strongly anisotropic distribution function of the fast electrons. Relaxation of this function due to the Coulomb collisions with charged particles outside the accelerating layer results in the appearance of the maximum in the particle distribution over the transverse velocities in the tail of the distribution function. The cyclotron instability of such a nonequilibrium distribution can result in generation of the plasma waves at frequencies above the pump wave frequency. These plasma waves may be related to generation of the Broad Upshifted Maximum feature in Stimulated Electromagnetic Emissions of the ionosphere.

A nonlinear interaction between Upper Hybrid and Bernstein waves is considered outside of the multiple electron gyroresonance frequency regions. In this case, an interaction kernel must be obtained from kinetic theory because wave numbers of Bernstein waves are greater then inverse thermal electron gyroradius. It is shown that nonlinear growth rate of the UH wave induced scattering to Bernstein wave increases essentially when the upper hybrid frequency approaches to an electron gyroharmonic from below in parallel with a decrease of Bernstein wave wavenumber. Thus, the Bernstein waves should represent a sink of the HF energy in the upper part of the pump frequency interval between two successive gyroharmonics. Such an effect can be responsible for the observed decrease of the SEE intensity for the pump frequencies below gyroharmonics.

S19-P04

TEMPORAL BEHAVIOR OF BROAD UPSHIFTED MAXIMUM IN STIMULATED ELECTROMAGNETIC EMISSIONS

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It's well known that the powerful HF pump wave transmitted into ionospheric F-region excites Stimulated Electromagnetic Emissions, which is detected on the ground. In the report we present results on the temporal behavior studies with a high frequency and temporal resolution of Broad Upshifted Maximum spectral feature in Stimulated Electromagnetic Emissions. The results were obtained with the use of new baseband system with 20 MHz sampling rate and 23-bit dynamic range at the SURA facility near Nizhny Novgorod, Russia. BUM is present in SEE spectra at the upshifted frequencies (from approximately 20 kHz up to 150 kHz) relatively to the pump wave frequency if the latter varies from slightly below (< 10 kHz) till well above (up to roughly 150 kHz) electron gyro frequency harmonic. The experiments were carried out for 4th and 5th gyro harmonics. In view to study the conditions for BUM generation in the modified ionosphere, the low pump diagnostic duty cycles (less then 5) after CW switch off were used. It was found, that characteristic times of BUM relaxation vary from 0.2 till 0.8 s increasing with a pump wave frequency offset from a gyro harmonic, with a decrease of the frequency shift as well as with time after switch off. Such times are much shorter then those for downshifted SEE features and correspond to the decay times of artificial small-scale (of order of $1-3$ m) irregularities.

S19-P05

HF DOPPLER RADAR STUDY OF CHEMICAL MODIFICATIONS OF THE IONOSPHERE

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A set of chemical release experiments and associated ground diagnostics have resulted in fair agreement between the data and the models. The chemical releases performed at an altitude of approximately 150 km were observed on frequencies of about 3.7 MHz at distances of 30 to 80 km at the ground using a portable HF Doppler radar. Its specifications are as follows. Operational frequency band of 3 – 30 MHz at 0.01 Hz intervals, pulse length of 500 ms, pulse repetition rate of 100 – 200 per second, receiver dynamic range of 80 dB, system bandwidth of 10 Hz, master oscillator of 10 – 9 stability, instrument error of 0.01 Hz at the maximum Doppler frequency shift of ~5 Hz. During the releases of gas clouds of barium, caesium, and lithium, three types of echoes were observed: from the clouds, from the F region, and from the clouds rebound through the F region. For masses of released chemicals of a few tens of kilograms, the echoes were observed during up to 405 min, and the Doppler shifts of the signals reflected from the clouds attained a maximum value of .5 to .0 Hz. When in Doppler modeling allowance is made for cloud drift and relaxation, the agreement between the data and the calculations is reasonable, and the analysis of signal mode structure provides further improvements. For masses of released chemicals of less than 1 kg, the drift observations have showed electric field intensities of 2 – 10 mV/m, and electron density changes by a factor of several times the ambient values.

S19-P06

ARTIFICIAL IONIZED REGION IN THE ATMOSPHERE AND ITS APPLICATIONS

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It is suggested to create Artificial Ionized Region (AIR) in the atmosphere at the heights of several of tens km in crossed beams of microwaves. To maintain ionization in AIR for a long time breakdown pulses should be sent periodically. Optimal conditions to achieve maximum ionization in AIR are discussed theoretically. It is shown that plasma concentration in AIR can exceed maximum concentration in the ionosphere by orders of magnitude. Several important applications of AIR creation are discussed. First, AIR can serve as an artificial "mirror" for radio and telecommunication in HF, VHF and UHF ranges. Second, each breakdown pulse is accompanied by stimulated optical emission from AIR. It means that powerful N_2 laser is formed in the atmosphere with the help of AIR. Third, AIR can be used for the investigation of complicated chemical processes with minor atmospheric constituents and for direct local action on ozone layer. The main theoretical results are confirmed in the laboratory experiments with strong microwaves.

S19-P07

INFLUENCE OF THE LONGITUDINAL INHOMOGENEITY ON INTERACTION OF WAVES IN STRIATIONS

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The existence of elongated small-scale plasma inhomogeneities (striations) causes substantial influence on waves interaction and formation of the spectrum of the stimulated electromagnetic emission (SEE). Up to now in the theory of high frequency (HF) heating of the ionosphere only transversal plasma inhomogeneity in striations was taken into account. Such inhomogeneity causes trapping of upper hybrid (UH) waves in striations. We analyse analytically propagation of UH waves in the resonator (single striation) taking into account inhomogeneity along the magnetic field line and in the transversal plane. It is found that the interaction of each UH eigen mode with the electromagnetic pump wave occurs only in a very restricted range of heights. Due to it the amplification of UH waves takes place at a rather low level. It means that the electron temperature in striations is not too high as it was predicted before. The obtained results allows us to esimate the intensity of lower hybrid (LH) oscillations, the spectrum and the intensity of UH waves that contribute to SEE spectrum and the influence of the discussed mechanism on the formation of superthermal electrons.

S19-P08

GENERATION OF INTERNAL GRAVITATIONAL WAVES BY PERIODIC HEATING OF AN IONOSPHERE BY USING "SURA" FACILITY

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Results of two serials (May 1998 and August 1998) of ionospheric modification experiments on investigation of wave disturbances of upper atmosphere are presented. Heating facility Sura (N. Novgorod, Russia) was used for modification ionosphere. At these experiments the antenna array dipoles phases were chosen in such a way that the antenna pattern was split in two beams inclined by 18° from zenith at the East West direction with width of each about 8°. The ordinary mode for the pump wave was used. The frequency of the pump was 5.75 MHz, the power of transmitters were 750 kW. Probe pulse transmitter was located at Zimenki, (130 km to the west from the Sura facility). Probe frequency was 5.68 MHz. Signals of pump and probe frequencies were recorded at Zimenki. Artificial IGW parameters are determined by variations of Doppler shift of received signal. Heating on off period was 10 min at May session and 15 min at August session. Doppler shift period was 20 min at May session (twice of heating period) and 15 min at August session (equal to heating period). The experiments have shown, that the perturbed area of an ionosphere is a source IGW. If the frequency of the pump wave turning on and off was lower than Brund-Vaisala frequency, IGW were as result of heating the ionosphere by powerful radio waves. If the frequency of turning the power on and off of the facility "Sura" was above than Brund-Vaisala frequency, parametric generation way of IGW had a place.

S19-P09

INVESTIGATION OF THE ELECTRON AND PLASMA BEAMS INTERACTION WITH IONOSPHERE: THE EXPERIMENT ONBOARD THE MIR STATION

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For the International Project INTMINS (INTerball-Mir-INSpire), plasma and electron beams are injected from the space station MIR into the surrounding plasma. The plasma-wave phenomena resulting from the injection are observed with the SPRUT-VI experiment and the Zond-Zaryad instrument flown onboard the MIR. The simultaneous ground-based observations of waves caused by electron and plasma injections are carried out by the INSPIRE network. During the first phase of the INTMINS Project (1995 – 1999) electron and plasma injections were performed when

the MIR was above the sites of the INSPIRE network. The second phase start on August, 1999 after the installation of the SPRUT-VI on outer surface of the MIR and include the experiment in the frame September 1999 Space Weather Month. The third phase have made in 2000 when the MIR and the INTERBALL-1 were on the same magnetic field line. The observations from the SPRUT-VI and the Zond-Zaryad, and the result of the INSPIRE network observations will be presented.

S19-P10

MODELLING OF OZONE PRODUCTION BY POWERFUL ELECTRON BEAM INJECTION AT STRATOSPHERE

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The balloon active experiment with electron beam injection in stratosphere is discussed. The results of modelling of injected beam behaviour and active action of it on ozone density evolution are presented. The main parameters of beam injection is varied to estimate more effective conditions for ozone regeneration and degradation processes. It is shown that the balloon payload for powerful electron pulse injection at stratosphere is prospective instrument for solving of modern ozone regeneration problems.

S19-P11

GENERATION OF ALFVÉN WAVE BY ORBITAL CRRES INJECTION OF BARIUM CLOUD IN MAGNETOSPHERE

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The results of analyses of Alfvén wave generation by magnitosphere Barium cloud injection during CRRES mission are presented. The experimental data obtained by means of simultaneous optical and radiophysical observations from Cuba during winter and summer 1991 campaigns. We examine the possible substorm triggering from data of HF radiotelescope measurements during substorm simulation G-8 experiment (geostationary injection). The significance of Alfvénic wave generation during artificial injection is discussed in context of current ideas based on artificial cloud - magnetosphere plasma interaction. It is shown that efficiency of Alfvén wave generation reach the MAX at time when the radius of expanding barium cloud is more than Larmor radius of background plasma ions but less than barium ions one. A variety of geophysical conditions is encountered.

S19-P12

RADIATION BELT PARTICLES MIRRORING BY PLASMA BEAM INJECTION IN BMA IONOSPHERE REGION

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The results of rocket experiment with dense caesium plasma beam injection to ionosphere plasma in Brazilian Magnetic Anomaly (BMA) are discussed. The effects of disappearing of energetic particles with energy more than 2 MeV are analysed. It means that dense beam plasma injection can be like umbrellafor rocket payload during such active action on energetic component of radiation belt population. It is shown that pulse of magnetic field from neutralisation current along geomagnetic field line during beam injection may be an effective mirroring of quasi trapped or precipitated energetic particles in BMA region. The practical advantage of this effect for protection of manned spacecraft is discussed.

S19-P13

THE MULTIPROBING ONBOARD MEASUREMENTS OF MAGNETIC FIELD VARIATIONS DUE TO XENON PLASMA JET INJECTION (APEX PROJECT)

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During the APEX mission with high energy electrons injections the effective spacecraft neutralisation was registered even without plasma jet operation. It was found that the main neutralisation current flows along magnetic field line or parallel to injected electron beam. The magnetic field cavity generation observed by two spaced onboard magnetometers during xenon plasma jet injection is investigated (in full altitude range of 450 – 3000 km) and the disturbance sometimes more than 2000 nT is found. The model of magnetic cavity or magnetic field anomaly generation is proposed and discussed.

S19-P14

DISTANT CORONA PLASMA PROBING ON 30 $R_\odot$ BY ELECTRON GUN OPERATION ONBOARD OF INTERHELIO-PROBE MISSION

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The programme of active experiments with electron beams injection at Solar corona plasma (INTERHELIOS project) is presented and discussed. Based on APEX mission data it is shown that by appropriate choice of beam parameters it is possible to measure the plasma density and magnetic field at some distance from spacecraft. The distant plasma probing by means of energetic electron beam injection is proposed as independent method of plasma diagnostic in INTERHELIOS mission. The possibilities to model the generation of different types of Solar radiobursts which are observed during active events on the Sun are also discussed.

S19-P15

TRANSITIONAL RADIATION OF THE MODULATED ELECTRON BEAMS IN THE ACTIVE BEAM-PLASMA EXPERIMENTS IN THE IONOSPHERE

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Waves excitation in the ionosphere by the modulated electron beams was observed in some active beam-plasma experiments. Transitional radiation due to the plasma inhomogeneities is one of the possible mechanisms of this radioemission. The frequency of this sort of radioemission is determined by the beam modulation; it can lie in the whistler band or in the high frequency band (more than electron plasma frequency). It can be also caused by the beam fronts. The role of the inhomogeneities can be played by the spacecraft surface, by the plasma jet, injected from the spacecraft board for its neutralization, by the ion-acoustic waves that perturb the background plasma density and by the accidental inhomogeneities of the background plasma (their level is especially high in the aurora regions). The radioemission characteristics (directivity diagram and total radiated power) are calculated for all these cases. The mechanisms that can amplify the radiated power are the resonant waves excitation in the local plasma resonance region, local Cherenkov resonance region and local Doppler resonance region, the transitional scattering of the modulated electron beam into electromagnetic waves in the stratified plasma, the excitation of the eigenmodes of the spatially restricted plasma. Estimations show that the radiated power is high enough to be detected.

S19-P16

INHOMOGENEOUS PLASMA DIAGNOSTICS VIA TRANSITIONAL RADIATION OF THE CHARGED BUNCHES

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Diagnostics of the density profile and other parameters of the inhomogeneous plasma objects using the transitional radiation of the modulated electron beams or charged bunches moving through this objects is proposed. The model of a cold planarly stratified plasma was treated. The electron bunch was considered to move along the plasma concentration gradient. The high frequency (non-resonant) and low frequency (resonant) components of the transitional radiation were studied. For the non-resonant radiation the magnetic field parallel to the electron bunch velocity was taken into account. The possibility to find out the plasma concentration profile from the measurement of the non-resonant transitional radiation of the relativistic modulated electron beam or charged bunch was shown analytically and using the computer simulation. For anisotropic plasma the magnetic field can be also found out. The measurement of the resonant transitional radiation of the charged bunch (this component is stronger than the non-resonant one) gives the information about the profile function of the concentration profile, *i.e.* the part of the plasma concentration profile where concentration grows along the bunch trajectory. The wake waves excitation in the inhomogeneous plasma was also studied for the simplest one-dimensional model. Consequently the conditions when the plasma object was not deformed by the wake field were found out.

S19-P17

DYNAMICS OF THE ELECTRON BEAM-PLASMA INTERACTION IN THE SPACECRAFT VICINITY

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We report the results of analytical consideration and computer simulation of the process of electron beam injection from spacecraft into ionosphere. The real structure of injected electron beam is quite complicated: beam appears as a thick helix gradually spreading into a hollow cylinder. Thus artificially injected beam forms a hydrodynamic flow along and, as a result of Larmor gyration, across the magnetic field lines. We reveal that the scenario of generation of beam driven turbulence differs from the "classical", previously described ones. The most important difference is the fact that the ionospheric plasma experience the quick (in times 0.01 ms) and strong turbulent heating. The further behavior beam-plasma system is determined by the coupling of the three fundamental processes: (1) emission of the primary Langmuir wave by injecting beam (beam-plasma instability), (2) parametric decay of the primary wave to the secondary one and ionic sound fluctuations ($L \geq L + IS$), and (3) the thermal damping of Langmuir waves.

S19-P18

TRANSIENT RESPONSE OF IONOSPHERIC PLASMA TO DISCHARGE ON SPACECRAFT SURFACE

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The use of high power in future space missions calls for high voltage power generation and transmission, typically > 100 V. The use of high voltage, however, causes serious interactions, such as electrical discharge, between space plasma and spacecraft whose potential generally becomes highly negative with respect to the plasma. Laboratory experiments and computer simulations are carried out to investigate the transient plasma response to the discharge on spacecraft surface in simulated Low Earth Orbit plasma environment. Once a discharge occurs, the positive current into the spacecraft body circuit drives the spacecraft potential positive. Part of spacecraft surface is covered by electrical insulator. The insulator potential is nearly zero before the discharge and stores positive charge from the surrounding plasma. Once a discharge occurs, the jump of spacecraft body potential drives the insulator surface potential highly positive. The positively charged insulator surface is exposed to the space plasma and electrons are rapidly attracted to the surface. A current path is formed between the discharge point and remotely located insulator surface through the plasma whose density is highly enhanced due to ejection of discharge plasma. Once the current path is formed, the insulator surface charge is provided as the discharge current. Therefore, the scale of discharge depends on whether the discharge path is connected to nearby insulator surface which serves as a capacitance. The measurement by a moving probe revealed that there is electric field between the discharge point and the insulator. Computer simulations show that the sudden increase of the spacecraft insulator surface induces ionization inside the positive sheath surrounding the surface. The sheath boundary expands outward and once the sheath meets the discharge point, the current path is formed and the discharge current keeps flowing until all the stored charge on the

insulator surface is released through the path.

S19-P19

EXPERIMENTS WITH SIMULATED BARE ELECTRODYNAMIC TETHERS IN A DENSE FLOWING, HIGH-SPEED PLASMA

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It has been proposed that operating in the orbital-motion-limited (OML) regime is especially beneficial for electron current collection to thin, bare electrodynamic tethers (EDTs) with dimensions on the order of a Debye length [1]. Predictions indicate that a bare tether will be a highly efficient collector of ionospheric electrons (per unit area) when compared to other current collection geometries at equal bias. This prediction of high efficiency is due to the result that the OML regime provides the highest possible current density. NASAs Advanced Space Transportation Programs mission called Propulsive Small Expendable Deployer System (ProSEDS), which is set to fly in Fall 2000, will be the first to use the bare-tether concept and will demonstrate high current and measurable thrust; the technology is also being considered for other future missions. However, a small, thin cylinder is not necessarily the best tether design when considering other practical factors such as tether lifetime. For example, to increase tether lifetime a tether based on ribbon-like geometry (*e.g.*, flat and wide) or more sparse structures of equal series resistance may be preferred; hence, these tethers would have dimensions exceeding a Debye length. These new geometries pose several questions that must be answered. For example, how will the current collection performance change as a function of geometry and Debye length when in an ionospheric plasma at orbital velocities? Does the orientation of the ribbon with respect to the direction of flowing plasma have an impact on collection efficiency?

In this presentation we describe chamber tests of simulated EDTs of different geometries operating in a dense, high-speed plasma. The geometries tested were cylinder, flat-ribbon, and a mesh (similar to the so-called Hoytether). For these tests, the 6-m × 9-m chamber operated by Michigans Plasmadynamics and Electric Propulsion Laboratory (PEPL)was used along with a PEPL/USAFdesigned Hall thruster for the plasma source. These tests were done, in

part, to support design efforts for the follow-on mission to ProSEDS called STEP-Airseds which will demonstrate multiple boost/deboost and inclination change operations over a period of a year and covering from below 400 km to above 700 km altitude.

[1] *Sanmartin et al., J. Prop. Power*, **9**, 353–360, 1993.

S19-P20

COMPUTER SIMULATION OF SPACECRAFT CHARGING AT THE CONDITIONS OF CHARGED PARTICLES INJECTION IN MAGNETOSPHERE

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The methodology of computer simulation of high-orbit spacecraft charging occurring under the condition of electron and ion injection into magnetosphere from the spacecraft is considered. The brief descriptions of developed computation algorithms and programs are given. The results of spacecraft charging simulation for various magnetosphere plasma environment and electron and ion injection parameter values are presented. Computations of the injected electron and ion trajectories in the spacecraft electric field were done. In terms of the computation data and GEO experimental results, the opportunities of the spacecraft charge neutralization by the electron and ion fluxes injection were analyzed. The methodology of on-board electron and ion spectrometer data interpretation for space plasma parameter measurements under the spacecraft charging conditions is discussed.

S19-P21

MATHEMATICAL MODEL OF SPACECRAFT CHARGING IN LOW-EARTH ORBIT

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Principle points of mathematical model of spacecraft charging under the conditions of cold ionosphere plasma and high-energy auroral electron impact are presented. The model includes the developed technique of effective ram ion capture surface construction in the vicinity of the charged spacecraft. The case of differential spacecraft charging is investigated in the model in terms of the analysis of various plasma component current balance for every spacecraft surface element. The simulation of charge accumulation processes on the surface enables to analyze the spacecraft charging dynamics. Examples of the electric potential distribution on the spacecraft surface for various charging conditions, and of the potential variations on the spacecraft design elements in cases of abrupt changes of environmental plasma parameters are presented. Various methods of the simulation result visualization are discussed.

S19-P22

EFFECTS OF INJECTED ELECTRON FLOW ON A MAGNETIC FIELD GENERATION IN THE NEARSATELLITE PLASMA

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A set of quasihydrodynamic equations to describe an interaction of injected field-aligned electron flow with slightly collisional ionospheric plasma is considered in terms of Alfvénic and magnetosonic perturbation quantities. Excitation of linearly polarized Alfvén waves (AW) in quasilateral-to-B0 direction by the slowly varying charged plasma column is studied in a frame of well-known problems with injected electron helicity. When the fluid velocity is equal to the Alfvén velocity, the most meaningful goals of the problem may be summarized as follows: (i) resonant/slowly-growing generation of the quasistatic magnetic fields (Alfvén wave packet envelopes); (ii) transformation of AW into ion-cyclotron modes in the range of ion hyrofrequencies and followed by strong absorp-tion by the ion plasma components. There are arguments to believe that in both cases the perturbations in the beam-plasma system may be stimulated by the presence of baroclinic effect. To explore these effects under plasma parameters measured in the point of injec-tion, we adopt a technique closed to "modified guiding center's loading" (MGCL) by *Naitou et al.* (*J.Comp.Phys.*, **38**, 265, 1980). The MGCL-technique is applied to Fourier-components of e beam density and temperature perturbations, in which the slowly vary-ing amplitudes are corrected by in situ plasma measurements. For different growth rates of AW, wave excitation frequencies and resonance detuning, this complex approach allows us to evaluate the low-frequency and time-averaged values of current density fluctua-tions. Comparison of active experiment measurements and model MGCL-approximation shows that for considered cases small parameters fluctuations in the beam-plasma system can cause the significant magnetic field perturbations.

S19-P23

ANALYSIS OF SPACECRAFT CHARGING ACCOMPANYING ION ENGINE OPERATION

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An ion engine that exhausts high velocity positive ions by an electrostatic acceleration always requires an electron source called a neutralizer that supplies the same amount of electron current as the ion beam to maintain the charge neutrality of the spacecraft. One of the severe problems for the ion engine is an abrupt failure of the neutralizer because the ion beam emitted from the ion engine without neutralizing electrons will drive the spacecraft to a negative potential of several kilovolts in a very short period of about an order of micro second, which will be determined by the capacitance of the spacecraft and the ion beam current density. As a result, when the failure of the neutralizer occurred, the spacecraft potential will be highly negative before any inhibit sequences of the engine by a controller becomes effective. In this paper, a one-dimensional ion flow emitted from the spacecraft was analyzed by the particle-in-cell plasma code, and both the transient plasma and corresponding spacecraft potential behavior was discussed.

S19-P24

REAL TIME OBSERVATION OF CHARGE ACCUMULATION IN PMMA UNDER ELECTRON BEAM IRRADIATION

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Real time charge accumulating process in PMMA under electron beam irradiation was observed using the PIPWP method. In space environment exposed to radioactive rays, discharging phenomena sometimes cause unexpected serious damages of spacecraft controlling system. The discharging process seems to be closely related not only to charge accumulating process on surface but also in bulk of dielectric materials. Therefore, it is necessary to investigate the charging process in the bulk of dielectric materials under radioactive ray irradiation. To apply the charge distribution apparatus to this theme, the PIPWP method has been modified. Using the improved system, the real time measurement of charge distribution in PMMA was carried out under electron beam irradiation. The increase of the electrons injected into PMMA was clearly observed with increase of the irradiation time. From the results of the charge distribution, the change of the electric fields and potential were also calculated. Furthermore, the decay of the charge distribution after irradiation was observed. From these results, it is proved that the real time measurement during irradiation is possible. In other words, a monitoring system of electron beam irradiation in spacecraft can be developed in near future.

S19-P25

TOTAL DOSE MEASUREMENT BY SMALL DOSIMETERS FOR SPACECRAFT

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The tolerance of the total dose from the space high-energy radiation environment is one of the concerns for spacecraft design. Some simulation models have ever evaluated the total dose effects. But the real total dose of the spacecraft in orbit hasn't understood. The satellites, which have small dosimeter sensors in several points, will be launched. This mission measures the total dose environment in spacecraft. The sensor design, calibration test results, and pre-simulation results are presented. The total dose model will be reconstructed from the acquired data and analysis.

S19-P26

ARTIFICIAL IONOSPHERIC DISTURBANCE STUDY BY RADIO PULSES SOUNDING

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The experimental results of artificial ionospheric turbulence studies by its sounding by short probing pulses are presented. Different types of scattered signals were discovered: "caviton" (CS), "plasma" (PS) and "aftereffect" signals. In this paper the latest results of CS studies are considered. CS appeared under the operation of the heating and probing transmitters at both O- and X- modes. Sounding by X-mode pulses allows to study the time and spatial CS evolution without PS influence. The time dependence of CS amplitude was mostly a series of maxima with periods, decreasing with the increase of the heater power and with the decrease of the difference of the probe and the heater frequencies. With the heater turning on CS period increased in some time, and then it fluctuated. The results of the experiments showed that the strong Lengmuir turbulence was excited, that qualitatively agreed with the numerical simulation of strong turbulence effects.

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S19-P27

SIMULATION OF POWERFUL EMISSION ACTION ON IONOSPHERIC PLASMA

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The results of simulation of nonlinear dynamic effects arising in the ionospheric plasma under the action of the disturbing wave using the numerical solution of nonlinear Schredinger equation for linear inhomogeneous plasma layer are presented. The spatial soliton structures of the field and plasma, their formation and penetration into the overdense plasma, their time evolution and spectra were studied. The periodic and chaotic stages of soliton emission were considered. The period of the soliton generation decreased with the increase of the amplitude of the incident wave. The soliton period increased in time for the periodic stage, and it fluctuated for the chaotic one. At the relaxation stage the soliton amplitude increased, and its width decreased. The numerical simulation shows the excitation of strong Langmuir turbulence and qualitatively interprets signals, scattered by the disturbed ionosphere.

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S19-P28

RF-INDUCED GLOW PATTERNS AROUND SPACECRAFT DIPOLE ANTENNAS: LABORATORY SIMULATION

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During the early phase of the OEDIPUS-C tethered sounding rocket experiment, the payload was separated into two parts connected by a conducting tether. Both sub-payloads carried a crossed-dipole antenna each; the antenna on the aft sub-payload received signals transmitted from the forward sub-payload's antenna. The aft sub-payload also carried a video camera for attitude measurement, which recorded the view of the forward sub-payload during the entire flight. Argon thrusters on the forward sub-payload drove the separation of the two sub-payloads. The Earth's magnetic field was directed almost perpendicular to the dipole antenna plane. While the thrusters were still running, the transmitter was turned on and luminous RF discharges were observed as the high fields close to the antenna accelerated the ambient electrons, which then caused light emission on collision with the Argon atoms. The observed light pattern consisted of glows both around the antenna and between the monopoles.

For laboratory simulation of the RF discharges, a scaled-down model of the OEDIPUS-C antenna has been built, consisting of two V-shaped monopoles. With this setup placed in the center of an axially magnetized laboratory plasma and transmitting an amplified signal, a similar glow pattern is observed. The shape and intensity of the glow pattern depends on the transmitted frequency and is strongest for frequencies close to the electron cyclotron frequency. In order to explain this glow, calculations of the fields in the magnetized plasma using quasistatic theory are carried out. It can be shown that a rotational current is induced in the plasma, resulting in circular electron trajectories at frequencies where no glow is observed, and in spiral trajectories with the spiral axis almost aligned with the external magnetic field at frequencies where a strong glow is observed. This suggests that accelerated-electron ionization of the ambient gas causes the glow.

S19-P29

NON-RECIPROCAL SHEATH WAVES ALONG STRUCTURES IN A MAGNETOPLASMA

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When a metal structure is immersed in plasma there exists a region of low electron density, called the ion sheath, adjacent to its surface. This sheath can act as a waveguide supporting a family of surface waves known as sheath waves. In the case of a cylindrical antenna, sheath waves strongly influence the antenna impedance. Also, they provide a mechanism for electromagnetic waves to propagate between widely separated points on ionospheric spacecraft. The latter has been demonstrated strikingly in the tethered sounding rocket experiments OEDIPUS A and OEDIPUS C, where propagation of sheath waves has been observed along a thin, cylindrical conducting tether oriented almost parallel to the magnetic field.

For a cylindrical structure in a plasma, oriented with its axis parallel to the ambient magnetic field, it is known that sheath waves can propagate along it and parallel both to its axis and to the magnetic field. Also, the case of propagation perpendicular to the magnetic field has been solved before and validated experimentally involving azimuthal propagation around the cylinder. There is also the possibility that a sheath wave can follow a spiral path around the cylinder. This would involve propagation at an arbitrary angle with the magnetic field. For the present theoretical study of these waves, a planar geometry is used with the ambient magnetic field parallel to the conducting surface and propagation at an arbitrary angle to the magnetic field. The results presented show two sheath wave modes propagating in opposite directions for each orientation of the magnetic field. These modes are non-reciprocal, exhibiting different passbands, different characteristic frequencies, and different cutoff frequencies. A scheme for their laboratory experimental validation is presented. A key feature is discussed, namely the degree to which the electron cyclotron frequency is visible in the theory and the laboratory and space experiments.

S19-P30

CONTROLLED EXPERIMENTS ON HF DUCTING AT AURORAL LATITUDES

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The bistatic digital sounder on the sounding-rocket double payload OEDIPUS C (OC) has been used to investigate wave ducting in density irregularities of the auroral ionosphere. The OC Receiver for Exciter (REX) was positioned below the High-frequency EXciter (HEX), their separation direction within a few degrees of the axis of the earth's magnetic field. Because the separation distance of about 1200 m was just sufficient to place the REX in the radiation zone of the HEX, the REX can be used to calibrate the radiated output of the HEX. The directly propagating pulse first arrives at and is recorded by the REX. Wave energy continues past the REX to a total reflection in the ionosphere below it and then back to the REX, thus adding an ionospherically reflected pulse to the record. The comparison of the direct and reflected pulse levels by the two-point OC sounder provides unique information about duct dimensions and density depletions. An analysis based on the radiation properties of the transmitter dipoles and on ray optics in cylindrical field-aligned density-depletion ducts shows that very shallow depletions of less than 1 % of the ambient density can explain the magnitudes and fluctuations observed in the reflected pulses. Duct density models with steep isodensity contours produce more realistic predictions of signal levels and their fluctuations with frequency than models with gently sloping contours. The finding of steep walls in ducts may help to identify the primary processes that create and sustain density depletions in the auroral topside ionosphere.

S19-P31

AMPLITUDE OF ELECTROMAGNETIC SIGNALS IN A PLASMA UNDER OBLIQUE RESONANCE CONDITIONS IN THE TWO-POINT OEDIPUS-C EXPERIMENT

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It was reported recently that observed levels of radiated whistler-mode signals in the two-point OEDIPUS-C experiment were about a hundred times greater than theoretical predictions. We have analyzed the features of a transmitter-receiver system under resonance conditions and have concluded that the experimental results can be explained taking into account both the resonance radiation of quasi-electrostatic waves by a transmitting antenna, and the resonance reception of these waves at the observation point. The voltage induced on the receiving antenna has been calculated using the fluctuation-dissipation relation for a nonequlibrium system consisting of the radiation field and receiving unit, as well as the reciprocity relation in a magnetized plasma (generalized Nyquist theorem for quasi-stationary systems). As a result we have found that the voltage induced on the receiving antenna is proportional to the length of the receiving dipole, the electric field in the incident wave and the receiving pattern in plasma. The latter is calculated in terms of the electric field radiated into the given direction, close to the resonance cone direction. The radiation field for an electric dipole with a triangular current distribution has been considered and compared with the theory of a point source. Corrections were made for thermal motion, whistler-mode diffraction and finite spatial scale of the transmitting antenna when estimating the level of radiating signal. An approach developed for the calculation of the voltage induced on the receiving antenna shows that under resonance conditions the effective length of a dipole antenna in plasma can be substantially greater than the vacuum effective length. This conclusion is of great importance for different applications connected with the recording of electromagnetic emissions in plasmas.

S19-P32

LARGE-SCALE WAVE DISTURBATIONS, ARISING IN MIDDLE LATITUDE IONOSPHERE AFTER FLIGHT OF A ROCKET

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1. Are analyzed of wave indignation registered during start of the pilotage ships "Souz", cargo ships "Progress", interplanetary stations and other objects. All objects are started through rockets "Souz", "Proton" and "Energy" with of Baikonur under a corner of an inclination of a plane of an orbit to a plane of equator $\sim$ 51.6 deg. The experimental material ($\sim$ 150 rocket starts) is received at multi channel inclined doppler sounding in the period with 1975 on 1999 years on HF - radio lines of Ashchabad-Tomsk, Tashkent-Tomsk, Dushanbe-Tomsk, Alma-Ata-Tomsk.
2. Characteristic post flight of feature of display wave disturbances, formed by rockets in area F ionosphere, in a spectrum of signals of inclined multi frequency multi line sounding, are considered. Two groups disturbances in the response of a signal are revealed. The connection of the revealed effects with helio-geophysical conditions and conditions of sounding are discussed.
3. A source of the first group disturbances in the response of a signal are of indignation of electronic density formed by a shock waves of torch of rocket in neutral gas of area F of the top atmosphere. The effect in a spectrum of a signal begins after crossing by a rocket of a plane of a radio line with occurrence an additional mode (modes). The time of existence of effect is insignificant and makes from tens seconds up to one - three minutes. The form of variations of frequency has asymmetric M - figurative kind. The variations of frequencies connected to passage through area of reflection sounding of a radio signal of internal gravitational and low-frequency acoustic waves are simultaneously registered.
4. The wave variations of frequency concern to the second group disturbances which occur in the response of a signal through some tens minutes after start. On the periods they concern to low-frequency acoustic disturbances

(LAD) and internal gravitational waves (IGW). The periods of waves, connected with IGW, do not fall below than 10 minutes. The cases of consecutive arrival several wave packets LAD and IGW are registered. The time of registration of these processes depends on geophysical conditions and makes units – tens minutes for LAD and tens – hundred minutes for IGW.

W1-01

LIVING WITH A STAR: A PROGRAM OF THE NASA SUN-EARTH CONNECTION THEME

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The U.S. National Aeronautics and Space Administration has initiated a new program element, the Living With a Star (LWS) Program. The overall goal of LWS is to develop the scientific understanding necessary to effectively address those particular aspects of the connected Sun-Earth system that directly affect life and society. Space weather is a key result of that connection. The components of LWS will be enumerated. These include an acceleration in the schedule of the Solar-Terrestrial Probe missions, plus the establishment of a Space Weather Research Network of missions, a targeted Data Analysis, Theory, and Modeling program, a series of Space Environment Testbeds, and education/public outreach efforts. Concepts which are presently under study for the future missions will be described. Although originally a U.S. initiative, the problems that LWS addresses are global in nature. Thus, it is recognized that LWS will be more successful if it features open data and encourages participation by international partners. The latest status of the LWS program in the U.S. will be reported.

W1-02

SPACE WEATHER ACTIVITIES OF ESA AND THE ROLE OF DATA COLLECTION AND PROCESSING

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ESA's interests in space weather are wide-ranging. In executing its missions, it must prepare its spaceraft to withstand the space weather environment. Effects on navigation and communications systems which include satellites also have to be considered. Manned missions involve potential radiation hazards which need to be accounted for. In addition to these space concerns, ESA has initiated wide-ranging studies of the requirements and potential architectures for a possible European Space Weather Programme.These will be presented. ESA has an on-going strategy to monitor the environments of its spacecraft. This monitoring is useful for the spacecraft itself for analysis of problems or as an on-board warning of hazardous conditions. The data also become a resource for the wider community for building environment models. In the future these data sources should form part of a space weather system. A future space weather system would inevitably include many data sources and a key element of a space weather system is the facility which brings these data together, processes them and delivers usable products.

W1-03

SPACE RADIATION ENVIRONMENT MEASUREMENT IN NATIONAL SPACE DEVELOPMENT AGENCY OF JAPAN (NASDA)

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The objectives of space-radiation-environment measurement in National Space Development Agency of Japan (NASDA) are to understand the mechanism of damages of the devices and materials by space radiation, to develop the Japanese space-radiation models for spacecraft design, and to study solar-terrestrial events for the space weather program. Since 1980', NASDA has developed and operated the space-radiation-measurement instruments on board ETS-V, ETS-VI, ADEOS, and Space Shuttle/Mir Mission, which is called "TEchnical Data Acquisition equipment (TEDA)" or "Space Environment Data Acquisition equipment (SEDA)". The obtained data is stored in the Space Environment and Effects System (SEES "http://sees.tksc.nasda.go.jp/") and is opened for the researches of above objectives. Those data are also available for scientific studies, especially by the ETS-VI which was unexpectedly launched into Geo-stationary Transfer Orbit (GTO), and by the Space Shuttle/Mir Mission #8 in which the Bonner Ball Neutron Detector (BBND) measured neutron spectrum inside the spacecraft. The TEDA and SEDA to be on board DRTS, MDS-1, ADEOS-II, ALOS, ETS-VIII, and JEM are now under development. NASDA will commence the operation of these instruments from 2002 to 2004.

W1-04

OVERVIEW OF THE L5 MISSION PLAN

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We studied an interplanetary space mission for research and forecasting experiment of space weather. The spacecraft will be deployed at 5 th Langangian (L5) Point of the Sun - Earth system for remote sensing of the Sun and the interplanetary space and in situ measurement of the solar wind plasma and high energy solar particle event. L5 point is an appropriate position for side-view observation of geo-effective CMEs and interplanetary plasma cloud. Optical and radio remote sensing will be dedicated for detailed tracking of CME launched toward earth direction. The mission will provide an excellent opportunity for not only space weather but also solar physics and solar terrestrial physics. However, due to its large distance from earth, a communication link will be limited severely. A concept of highly intelligent data transmission based on autonomous onboard data analysis with high performance onboard computer are studied for efficient data downlink with event selection.In this paper, overview of mission concept and status of study are reported.

W1-05

THE BEST USE OF HELIOSPHERIC PHOTOMETRIC IMAGES – TIME-DEPENDENT TOMOGRAPHY OF HELIOSPHERIC FEATURES USING GLOBAL THOMSON-SCATTERING DATA

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Precise photometric images of the heliosphere are expected from the Air Force/NASA Solar Mass Ejection Imager (SMEI) now scheduled for launch in December 2001, and similar images may become available at some future date from all-sky cameras proposed for other space missions. To optimize the information available from these instruments, their two-dimensional sky images need to be interpreted in three dimensions. We will describe the precision required for this, and our current progress in obtaining this precision using images from the SMEI flight optics on the ground.

We have developed a Computer Assisted Tomography (CAT) program that modifies a time-dependent three-dimensional kinematic heliospheric model to fit Thomson scattering observations from the Helios spacecraft photometers. The tomography program iteratively changes these models to least-squares fit observed global brightness data. The short time intervals of the kinematic modeling ($<$ 1 day) force the reconstructions to depend on outward solar wind motion to give perspective views of each point in space accessible to the observations. We plot these models as density Carrington maps and remote observer views for the Helios photometer data sets and compare times of solar minimum and maximum.

W1-06

MONITORING SOLAR ACTIVITY ON THE FAR SIDE OF THE SUN FROM SKY REFLECTED LYMAN ALPHA RADIATION

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Solar active regions are known to be brighter in Lyman α radiation than the quiet sun. Accordingly, they illuminate more H atoms in interplanetary space through resonance scattering. As we show here, this excess of illumination related to active regions is clearly seen in full-sky Lyman α maps recorded by the SWAN instrument on board SOHO, including those excesses resulting from active regions which are on the far side of the Sun. Since solar activity is most often connected to solar active regions, this technique could be used in the future to improve the quality of Space Weather forecast, by earlier detection of the birth of a new active region on the far side of the sun, before it comes into Earth's view at the East limb. These data can also be used to predict short term variations of the UV flux emitted by the sun.

W1-07

PROSPECTS FOR SPACE WEATHER OBSERVATIONS WITH THE PROPOSED LOW FREQUENCY ARRAY

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A large new HF/VHF receiving array known as the Low Frequency Array (LOFAR) has been proposed for radio astronomy and atmospheric science observations. Alone or with an appropriate transmitter, LOFAR could be used for a number of interesting space weather measurements. Prominent among these is ground-based radar observations of the solar corona, a technique known as solar radar. Solar radar was shown to be a viable and interesting technique for the study of the sun by *James* [*Astrophys. J.*, **146**, 356, 1966]. Solar radar frequencies lie in the 10 to 100 MHz range, and scatter from the coronal plasma occurs at or near the corresponding plasma resonance level, generally between one and five solar radii from the center of the sun. Because of this, solar radar is an ideal technique for the study of coronal structure and dynamics, including wave activity, turbulence, and explosive events such as CMEs. What is new today is the possibility of high resolution imaging radar observations and the opportunity to participate in multi-instrument solar observing campaigns in which the collective database provides enhanced possibilities for understanding the observations. Past observations and their theoretical interpretations will be reviewed, and past and potential solar radar systems, in particular LOFAR, will be discussed.

W1-08

SIMULTANEOUS IMAGING OF ELECTRON DENSITY AND MAGNETIC FIELD DISTRIBUTIONS IN THE MAGNETOSPHERE

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The current collection of magnetospheric observations consists almost entirely of in situ measurements at isolated spacecraft positions. A novel remote sensing technique for simultaneously imaging the plasma density N and the magnetic field B is proposed. The imaged region of the magnetosphere can be several Earth radii in extent. Simultaneous measurements of both group delay and Faraday rotation of radio waves propagating through the magnetosphere yield both total electron content (TEC) and Faraday rotation angle, which is the integral of electron density weighted by some known function of the magnetic field and ray path. These data can then be inverted to obtain estimates of the three-dimensional spatial distribution of N and B. The geometry of the ray paths determines the number of components of B that can be resolved. Simple multi-satellite simulations and common data processing techniques introduce this new application of tomography: Magnetospheric TEC measurements yield a map of N, which is then combined with Faraday rotation angle measurements to produce a two-component map of B in the plane of observation. The successful tomographic reconstructions provide a straightforward illustration of the practicality of using this technique to map the magnetospheric plasma density and magnetic field in two or three dimensions. Furthermore, simultaneous images of N and B are of great topical interest to geospace science because of their direct and immediate relevance to current questions regarding magnetospheric structure and dynamics. Sensitivity analysis is performed.

W1-09

DESIGN, MODELING, AND CONSTRUCTION OF SOLAR-TERRESTRIAL DATA ANALYSIS AND REFERENCE SYSTEM (STARS)

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For the space weather forecasting, our understanding of the relationship of cause and effect in the solar-terrestrial system is significant. In these days, a large amount and variety of satellite and ground-based observation data are available. As more satellites launched, so quantity and quality of the data increase. New system is, thus, required that can refer and analyze the variety of data. We have been constructing a software system, which is named Solar-Terrestrial data Analysis and Reference System (STARS). This system provides us with a data analysis circumstance on personal computers (PC). Using this system, we get a variety of data through the Internet, save them in the local harddisk (HD) as a database, and take views of one or more data plots on a specific date; this helps us to find new phenomena and relationships between the observation data. In the development of the system, a software development methodology was adopted which is called Object Modeling Technique (OMT). The OMT enables us to separate researchers and programmers. Researchers come free from the software programming and can concentrate on the data analysis. Programmers are not expected to understand (physical) properties of the observation data. The initial version of STARS has been already distributed to the test users. Including the comments, requests and reports from the test users, we now continue to develop and reconstruct the initial version. In our talk, we discuss the software designs and programming techniques of the STARS. Then, we perform a short demonstration of the system to show how it works and helpful to the space weather forecasting studies. For example, we first select a storm/substorm event. Next we show the observation data plots by the satellites along with the satellite orbits.

W1-10

THE TECHNIQUES FOR HANDLING AND PROCESSING OF MAGNETOMETER DATA CIRCULATED IN INTERNET

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The magnetometer data become one of the widely and often used data in space weather research and operation. Nowadays we have more than 75 magnetic observatories presented in Internet in real time, but no one common format adopted to display data in Internet. Such situation lead to limitations in the usage and analysis of magnetometer data. In this paper we consider some prospective ideas how to simplify the collection of data circulated in Internet. First of all we propose the simple html-form with link to data files. Such procedure gave us possibility to collect data on-line and process its automatically for research purposes. The procedure based on the next standards: – standard for graphical form, – standard interface to handle data, – standard for data storage. Next step is how to display the connection with satellite data. For the case we take ACE magnetometer data and stacked it with ground-based data. Such graphs demonstrate connection between solar wind variations and magnetic activity. To infer the connection between solar wind and ground magnetometer data we propose to use the set of tools as the different methods of spectral analysis, LT-UT mapping and 2D and 3D godographs. The stacked and summary plots lead to more clear understanding of the spacial and temporal processes in the outer space.

W1-11

A FORECASTER'S REVIEW OF REQUIREMENTS FOR OBSERVATIONS FOR SPACE WEATHER OPERATIONS

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Observations of the solar terrestrial environment are the primary requirement for operational space weather services. Recent studies highlight the observations that are now available and identify additional measurements that are necessary to provide modern space weather services. The observations may be of domains of the environment that directly affect users of space weather information. These users include space crews, satellites, navigation and communication systems, and electric power systems and other long-line systems. A second observational requirement is provision of initial conditions for models of the environment. Models allow forecasts of future activity or provide information about the environment at locations where no measurements are made. A third category of requirements is to provide measurements to develop models and techniques that will improve future space weather information. In the U.S., the National Space Weather Program and the National Space Weather Architecture Study have reviewed the observations and associated models to improve space weather services to meet future requirements. This presentation reviews the results and recommendations of those studies, combined with the experience of Space Environment Center in providing space weather services in the United States.

W1-P01

SPACE WEATHER IN CHINA

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In the past two decades, one of the most important achievements in solar-terrestrial physics makes us realize the fact that there exists adverse space weather above $20-30$ km or up to thousands km above the earth, which are acting like the fierce wind, rainstorm, fulmination that can cause disasters to our daily life such as living, traveling and working. These adverse space weather can also do harms to our high technological systems such as satellites, communication, navigation, tracking, electric network and our health or even lives. As we are facing these adverse space weather in developing high technology, solar-terrestrial physics is entering into a new epoch of safeguarding our high technology, which generates a new discipline "space weather". Space Weather is rapidly becoming a major scientific activity worldwide, and thus forming a national behavior of various countries. This trend reminds us of what had been done to our meteorological environment of the earth by international communities in the 50th. As far as we know, the environment that affects the earth and human life should include the following four spatial layers: solid earth, ocean, atmosphere and space, which are closely related to each other and construct a complete scientific system of understanding the terrestrial environment.

Here, we would like to present some comments on space weather of our own and thus exchange our ideas with other scientists. On the other hand, emphasis is put on the introduction of scientific activities and exploration projects carried out in China.

W1-P02

AUTOMATIC AND REAL-TIME DETECTION OF GEOMAGNETIC SUDDEN COMMENCEMENT BY TRAINED LIFTING WAVELET FILTERS

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The earth's magnetosphere is suddenly compressed when it is collided with the interplanetary shock emitted from the sun. Sudden increase of the magnetic field which is called geomagnetic sudden commencement (SC) is observed in the magnetosphere. On the ground it is detected almost simultaneously all over the world. Real-time detection of SCs is very important because SCs are frequently followed by severe geomagnetic storms during which many hazardous accidents such as anomalies of electronic circuits on board satellites, large scale power line failures in high latitudes may occur. SC phenomenon in low latitudes appears in a sequence of geomagnetic horizontal (H) components as a sharp increase of them. We propose a method for detecting such SC phenomena automatically and in real time by using a lifting wavelet filter trained with several SC-waves detected by experts in advance. Lifting wavelet filters are biorthogonal wavelet filters constructed from initial biorthogonal wavelet filters by adding lifting terms which contain free parameters. Training of lifting wavelet filters is to determine the parameters so as to vanish high frequency components computed by the initial wavelet filters, adapting to samples of SC-waves. Since the trained lifting wavelet filter has the feature of SC, the location of SCs can be found by applying the filter to a sequence of H-components. There are several stations in the world to obtain sequences of H-components. We design a lifting wavelet filter using samples of SC-waves in each station and apply the designed filter to a sequence of H-components to detect SCs. By checking whether or not SCs occur simultaneously in all the stations, we can identify the location of SCs with high accuracy.

W2-01

ASSET VALUES IN SPACE, INSURANCE LOSSES, AND PROSPECTS FOR THE FIRST DECADE OF THE 21ST CENTURY

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Space insurance provides coverage for loss or failure of satellites, launch vehicles and other space payloads. As space activity increases and spacecraft become increasingly complex, the role of space insurance in fostering new technologies increases in importance. The space insurance community must develop a deeper understanding of the forces acting in the space environment. We present an introduction to space insurance, historical space insurance experience and prospects for the future of the space insurance market.

W2-02

SPACE ENVIRONMENT EFFECTS ON INTERPLANETARY SPACECRAFT

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Although similar in many respects to the effects observed in the Earth's environment, the extra-terrestrial space environment can pose unique threats to interplanetary spacecraft. Just as at the Earth, discharges, single event upsets, and total ionizing dose have all been observed to have produced anomalies on interplanetary missions. Although often merely of nuisance value at the Earth, these anomalies can have significant impact on an interplanetary mission as the ability to interpret and correct their effects can be seriously compromised by the huge communication distances involved in interplanetary missions and the lack of in-situ environmental information. Typically, the differences between the Earth and, as an example, the jovian radiation environments and their effects are more quantitative than radically different. In some cases, however, such as for hypervelocity micrometeoroid impacts near the Sun where velocities can exceed 500 km/s, new physical phenomena may play a part. This talk will discuss these differences in environments and effects in the context of several recent (Voyager, Magellan, and Galileo) and planned (Pluto Kuiper Express Europa Orbiter, Solar Probe, and the Interstellar Probe) missions. Although fortunately ultimately survivable, anomalies observed on the earlier missions will be reviewed with emphasis on the mitigation procedures followed and the impacts these design changes had on the subsequent success/ failure of the missions. The unique challenges posed by the new missions will also be explored-challenges that range from exceptionally harsh radiation environments to the challenges of truly long duration missions (20 – 30 years) at extreme distances from the Earth requiring methods for on-board evaluation and mitigation of in-flight anomalies without human intervention. Topics of particular concern will be the charging and radiation environments (both observed and projected), micrometeoroid impacts, and spacecraft charging.

W2-03

SPACECRAFT ENVIRONMENT INDUCED ANOMALIES: EXPERIENCE AND PROSPECTIVE AT ESA

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Several spacecraft have experienced failures and anomalies due to the space environment. Analysis and identification of the anomaly cause is crucial in order to be able both to take corrective actions during operations and to improve future design. Commercial and confidentiality issues in this domain also need careful consideration The Space Environments and Effects Analysis Section at ESA has a strong background in dealing with all these aspects and is also undertaking various generic research activities in these fields. Examples of these activities and an outlook will be presented.

W2-04

DEMONSTRATION OF THE RICE MAGNETOSPHERIC SPECIFICATION MODEL INCLUDING RELATIVISTIC ELECTRONS

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We are developing a version of the MSM designed to specify fluxes of trapped electrons from 500 keV to 5 MeV, the Energetic Electron Magnetospheric Specification Model. The EEMSM employs the fully-adiabatic model of *Kim and Chan* [1997] with the *Hilmer-Voigt* [1995] magnetic field model. It uses CRRESELE for starting fluxes and for dynamic inner boundary fluxes at $2.5R_E$. In the EEMSM CRRESELE is driven by a neural network-specified Ap15 that is driven by solar wind parameters. The dynamic outer boundary electron flux specification at GEO is provided by a two-dimensional interpolation of GEO satellite data or by a neural network that is driven by solar wind parameters and by lower energy electron fluxes specified by the MSM. The goal is to push adiabaticity to its limits, learn what those limits are and then use alternate drift methods or parameterization to adjust energization and/or radial drift processes to mitigate shortcomings. An initial version of the model has been run for the November 1993 storm. To understand the effects of changes in the magnetic field configuration on relativistic electron fluxes we have developed a display that shows the equatorial crossing points of magnetic field lines in the noon and midnight meridians simultaneously with the model relativistic electron fluxes. Of particular interest are the electron flux changes seen during a dayside sudden compression and during substorm dipolarizations and distention on the night side. Movies showing these electron fluxes and simultaneous changes in field line positions and model fluxes will be presented.

Hilmer, R. V., and G.-H. Voigt, A magnetospheric magnetic field model with flexible current systems driven by independent physical parameters, *J. Geophys. Res.*, **100**, 5613–5626, 1995.

Kim, H.-J. and A. A. Chan, Fully-adiabatic changes in storm-time relativistic electron fluxes, *J. Geophys. Res.*, **102**, 22107–22116, 1997.

W2-05

SATELLITE ANOMALIES: RESULTS FROM THE NATO ASI STORMS 2000 MEETING

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Modern spacecraft components have been showing an increasing susceptability to hazardous effects of the space environment. This talk will report on satellite anomalies issues presented and analyzed at the NATO ASI on Space Storms and Space Weather Hazards in Crete, Greece, last June. Particular emphasis will be devoted to investigations of recent satellite anomalies and approaches to mitigate space weather effects.

W2-06

SATELLITE ANOMALY ASSESSMENTS: OPERATIONS, HISTORY, DATABASING, AND PRODUCT DEVELOPMENT

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The current operational process for assessing space environmental effects on satellite anomalies in near-real time has a history of significant constraints. It has been troubled by lacks in: personnel experience, applicable data and model availability, consistency, automation, and database sharing. In an effort to alleviate such problems, AFRL is in the process of developing an all-inclusive satellite operations environment product that would automate the various aspects of satellite anomaly post-assessment, "nowcasting" (or warning), and forecasting. It will include satellite-specific, hazardous region-specific, and orbit-specific processes and related output products. Satellite charging, single event upsets, communications effects, and drag are considered with a suite of real-time data and state-of-the-art models that specify and forecast neutral atmosphere, ionospheric scintillation, auroral currents, inner and outer radiation belts, solar wind conditions, and meteor showers. Each aspect of the process and current product will be presented, along with future development considerations, concerns, and solicitations.

W2-P01

EFFECTS OF SPACE PARTICLE RADIATION ON LOW EARTH SATELLITES OF INDIAN SPACE RESEARCH ORGANISATION (ISRO)

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Since March 17, 1988, ISRO has launched a series of satellites in low earth orbits for remote sensing and scientific applications. Its first generation remote sensing satellites IRS-1A and IRS-1B carried Hard-Wired satellite systems and no adverse affect of space environmental disturbance was recorded except an increase in orbital decay by few meters on March 13, 1989,the day of peak Solar activity of the previous Solar cycle # 22. ISRO 2nd generation remote sensing satellites IRS-P2, IRS-1C, IRS-P3, IRS-1D and IRS-P4 launched in years 1994 – 1999 carried micro-processors based systems on-board, encountered soft and hard errors, memory corruption in RAMs mostly when spacecraft passed through South Atlantic Anomaly (SAA) and high latitude regions that harbour large fluxes of trapped particle radiation that mimic SAA at 700 to 800 km spacecraft altitude.Thus an indication of technological susceptibility to natural radiation environment.Anomaly events due to magnetic field sudden reversal in sign were also recorded during period of space disturbance, as confirmed through Auroral Electojet (AE) magnetic sub-storms indices and plots. This paper presents the details on space environment conditions prior to, during and after the spacecraft anomaly events which may be caused by the trapped radiation, field-aligned current and recurrent magnetic storms during the period 1994 – 1999. An enhanced spacecraft state-of-health monitoring is planned and contingency plans are being prepared which would permit recovery from any likely damage during the years 2000 – 2002 as Solar eruption continues beyond maximum. The study on space environmental conditions affecting satellite components and a comprehensive view of the complex processes that modulate energetic particles in the magnetosphere,can help in satellite operation planning, selection of satellite systems that are less susceptible to space radiation.

W2-P02

CORRELATION OF RADIATION EFFECTS IN ØRSTED SATELLITE INSTRUMENTS AND SYSTEMS WITH HIGH-ENERGY PARTICLE OBSERVATIONS

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The CPD high-energy charged-particle detector instrument comprises an array of 6 solid-state silicon detectors with various shieldings and depletion depths. Four of the detector units are looking upward along the mast while two are looking to the side. They are connected to pulse-height analyzers to provide energy spectra of the high-energy particle radiation in space. The presentation will describe the experiment and focus on the initial results. The high-energy particle radiation affects the instruments and systems of the Ørsted satellite causing, among other, deterioration of Star Imager (SIM) performance, and bit-flips in the satellite computer (CDH) memory. These effects mainly occur in the South Atlantic Anomaly, where the weak geomagnetic field allows the radiation belt to extend down to the Ørsted orbit, and in the Auroral Zones. The CPD observations are correlated with the occurrences of adverse radiation effects on the satellite instruments and systems. It is shown, that most events are related to the hard, penetrating radiation, and that these events are strongly height-dependent. Another group relates to softer radiation, typical of the auroral zone, which probably casuse sparking due to excessive dielectric charging.

W2-P03

ACTIVITIES RELATED TO SATELLITE ANOMALY RESEARCH IN JAPAN

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Space weather research is conducted in order to understand how solar activity induces such phenomena as interplanetary disturbances, geomagnetic storms, satellite anomalies, and so forth. Contributing a part of this research, we are compiling a database of Japan satellite anomalies. At the National Space Development Agency of Japan, the Space Environment and Effects System (SEES) database has already been established to study the space environment, and to distribute space environment measurment data to users via the World Wide Web. By adding the satellite anomaly data to SEES our initial aims are to reveal the cause of satellite anomalies and effects of space environment variation on satellites, as well as to enlarge the scope of SEES itself. At the current stage, we are collecting data on Single Event Upsets (SEU) and ElecroStatic Discharges (ESD) which have occurred on the GMS series, ETS series, and MOS-1 satellites. SEUs and ESDs are satellite anomalies which are thought to be caused by solar-terrestrial phenomena. In this talk, we will also present the results of analyses related to SEU/ESD and geomagnetic storms.

W2-P04

SPACE ENVIRONMENT DATA ACQUISITION EQUIPMENT (SEDA) ON BOARD MISSION DEMONSTRATION TEST SATELLITE-1 (MDS-1)

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The objective of Mission Demonstration test Satellite-1 (MDS-1) developed by the National Space Development Agency of Japan (NASDA) is to verify the function of commercial parts and new technologies of bus-system components in space. The following five experimental modules are on board MDS-1: (1) Commercial Semiconductor Device (CSD), (2) Terrestrial Solar Cells (TSC), (3) Common Pressure Vessel type battery (CPV), (4) Solid State data Recorder (SSR), and (5)Parallel Computer System (PCS). MDS-1 is to be launched into Geo-Stationary Transfer Orbit (GTO), where on-board experiments will be conducted in the more severe radiation environment of GTO rather than in the milder environments of Geo-stationary Earth Orbit (GEO) or Low Earth Orbit (LEO).

The Space Environment Data Acquisition equipment (SEDA) is also on board MDS-1, to measure the radiation environment and thus support the analysis of data obtained by the other experimental modules on board MDS-1. The information on the radiation environment will also be used to develop a precise radiation-belt model.

SEDA consists of four instruments; (1) Standard DOse Monitor (SDOM) monitors the electron and proton flux; (2) DOSimeter (DOS) has fifty-six sensors which are distributed inside the other experimental modules and the MDS-1 body, and measures radiation dose at each sensor location; (3) Heavy Ion Telescope (HIT) monitors the flux of heavy ions from He to Fe; (4) Magnetometer (MAM) has a 3-m deployable mast, at the end of which the MAM-sensor is mounted (to prevent the electromagnetic disturbance by the MDS-1 body), and measures the Interplanetary Magnetic Field (IMF).

Operation of MDS-1 will commence in 2001. Information on the radiation environment gathered by MDS-1 will be released via "http://sees.tksc.nasda.go.jp".

W2-P05

IMPACTS IN ELECTRONICS ON SPACECRAFTS CAUSED BY SOLAR AND GALACTIC ENERGETIC PARTICLES: EXPECTED TIME VARIATIONS AND DEPENDENCE OF SPACECRAFT POSITION

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Galactic cosmic rays and solar energetic particles pose various threats to electronic components on satellites. Such particles, that pass through the spacecraft's shielding with almost no attenuation, form an ionization track within the sensitive volume of the component, leading to so-called single event phenomena (SEP). Some of these phenomena, such as single event upsets (SEU), cause software errors that can usually be corrected through error detection and correction algorithms or by hardware reset. Others, like single event latchup (SEL), cause permanent damage in the component and consequently lead to system failure. The probability of occurrence of such events increases by orders of magnitude during large solar particle event, especially for satellites in geostationary and polar orbits. Early reliable warning about the occurrence of such a large event is crucial for the protection of critical electronic components, since damage can be avoided by disconnecting the components from power. In this paper we propose a novel method for such a warning. The method is based on the detection of the most energetic particles from a large solar event that reach the earth's surface using neutron monitors (this method will be described in details in other papers presented by ICRC-Israel Cosmic Ray Center). After few minutes of starting of the great Flare Energetic Particle (FEP) event from ICRC will be send Alert with the information on expected flux and energy spectrum of FEP out of the Earth's magnetosphere. We describe how on the basis of this information can be automatically calculated expected radiation hazard and its variation in time for different type of satellites and spacecraft in dependence of their orbits. If the radiation hazard will be expected to be dangerous for some important parts of electronics, they can be for the short time switch off from the power or will be protected by some other way (it will be a problem what special experts must solve). The main advantages of this method are the high resolution of the neutron monitors and low false alarm probability, as compared to space-based warning systems.

W2-P06

MAGION-5 SOLAR ARRAY DEGRADATION CONNECTED WITH THE 30 SEPTEMBER 1998 SOLAR EVENT

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MAGION-5 (68.5 kg) launched on 29 August 1996 into an orbit with apogee 20000 km and perigee 700 km as a part of the INTERBAL Mission was reactivated in May 1998 after being out of operation for 20 months. The s/c destinated for study of the Earth's magnetosphere continues to be active up to now (May 2000) with some limitations caused mainly by limited power resources. This problem occured in immediate connection with the Solar Proton Event on 30 September 1998. A step-like solar battery degradation of more than 1 % was observed. An analysis of this effect and its consequences as well as a note on possible radiation belt influences will be presented.

W2-P07

SAAPS – SPACECRAFT ANOMALY ANALYSIS AND PREDICTION SYSTEM

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A spacecraft anomaly analysis and prediction system (SAAPS) is under development. The three main modules of SAAPS are: 1) a database of space environment data and spacecraft anomalies, 2) tools to analyze the space environment at times of anomalies, 3) models to predict the environment and anomalies. The database will contain solar wind data, geosynchronous electron flux data, and geomagnetic indices. The database is updated in real time. The analysis module consists of different statistical and neural network tools that should help to identify the cause of anomalies. The prediction module contains neural network models to predict various space environment parameters and spacecraft anomalies. As the database is updated in real time this also enables forecasting. In this work we examine the relations between different anomaly data sets and the space environment. We also discuss the models for prediction of the electron flux at geosynchronous orbit and the prediction of spacecraft anomalies.

W3-01

MAJOR SOLAR ACTIVITY IN APRIL–MAY 1998

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April and May 1998 witnessed a notable outburst of solar activity, early in cycle 23. In particular, active region 8210 was associated with a series of energetic coronal mass ejections (CMEs) during its disk passage. The seven fast CMEs (> 600 km/s) linked to this region between 23 April – 9 May were associated with M- and X-class soft X-ray flares, strong interplanetary shocks (and associated radio emission), intense geomagnetic activity, solar energetic particles (SEPs), and Forbush Decreases of the cosmic ray intensity. At the Sun, the CME source regions were notable for their extended dimming regions (*Thompson et al.*, 2000) and the involvement of trans-equatorial loops (*Khan and Hudson*, 2000). Associations will be made between solar events and the outstanding solar-terrestrial events during this period.

W3-02

THE SEPTEMBER 1999 SPACE WEATHER MONTH AND SPARC: A WEB-BASED RESEARCH AND EDUCATION TOOL FOR THE SPACE PHYSICS AND AERONOMY COMMUNITY

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The SPARC (Space Physics and Aeronomy Research Collaboratory) project is a next generation, web-based collaboratory for space physicists and aeronomers. The project represents a continuation and expansion of the Upper Atmospheric Research Collaboratory (UARC), in which over a six-year period a team of space physicists, computer scientists, and behavioral scientists evolved a suite of collaboration capabilities to provide rich, real-time access to a wide variety of upper atmospheric data and modeling resources. SPARC expands on this theme, allowing space scientists to engage in the planning of research, the observation and sharing of both real-time and archival data sources and the manipulation and understanding of complex computational models. It facilitates collaboration among space scientists working at the same time, as well as scientists working at different times across multiple time zones. It also provides unique outreach and educational products at appropriate pedagogical levels, providing the general public with exciting and fresh information on space science. Furthermore, the web-centered design strategy of SPARC's infrastructure helps it to function in an extremely heterogenous environment of computational resources (*e.g.*, different computational platforms, network links with highly variable bandwidth, latency, and loss characteristics), administrative domains, and individual preferences.

W3

The SPARC project provides access to data sources supplied by 20 different facilities which combine to supply nearly 200 different real-time (or near real-time) data and predictive products. The experimental complement comprises ground-based instruments including the suite of incoherent scatter radars [Sødre Strøfjord, Millstone Hill, Arecibo, EISCAT Tromsø, EISCAT Svalbard, and Jicamarca], several components of the SuperDARN system, several Digisonde stations, magnetometers, a riometer, and others. Satellite-based data sources include GPS beacons for TEC and scintillation measurements, POLAR UVI and VIS imagery for defining the auroral oval boundary, ACE and WIND IMF and solar wind measurements, most in real-time. Global current and forecasted ionospheric and thermospheric parameters are determined from operating a nested-grid version of the NCAR TIGCM model, using as input, real-time satellite IMF measurements when available, or ground-based Kp measurements when the satellite feeds are down. Real-time model operation is possible by employing multiple nodes of the SGI Power Challenge at the Center for Parallel Computing at The University of Michigan. Additional models will soon be integrated with the program.

In addition to describing and demonstrating the web-based SPARC software, this paper will describe results from the S-RAMP 1999 campaign, designed to monitor the effects of geomagnetic storms on the upper atmosphere, as well as the recovery of the atmosphere from storms during the International Space Weather Month, September 1999. The SPARC project can be found at http://sparc-1.si.umich.edu/sparc/central. Training sessions during the poster sessions will be used to introduce the SPARC suite of visualization tools, emphasizing the September Space Weather Month data sets.

W3-03

THE INTERPLANETARY ASPECTS OF THE 21 – 23 SEPTEMBER AND 21 – 22 OCTOBER, 1999 EVENTS

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The magnetic field and plasma properties of the 21 – 23 Sept. and 21 – 22 Oct, 1999 high pressure geoeffective events are described. If we categorize such intense' events as either transient (*e.g.*, ejecta, ICME's, magnetic clouds, etc.) or quasi-periodic (CIR's, etc.), they fall into the latter category, and we notice that they were one month apart. They were apparently the result of the development of a fast stream ramming into slower plasma causing compression of the plasma, and the consequential increased field intensity, density and temperature near the interface. Consistent with this,in both cases,the heliographic current sheet was crossed several times over a two day period and, in fact, in the October event HCS crossings bracketed its high pressure, low plasma β region. The September event was more complex where the plasma β varied widely across its extent. Both events were geoeffective having Dst values smaller than -100 nT at minimum; the September event had a min Dst of -149 nT and the October event has a min Dst of -231 nT. Also, in the October case there was an SSC caused by the abrupt increase in solar wind pressure caused by a fast forward interplanetary shock at the leading edge of the solar wind event. The September case also had an SSC caused by a sharp increase in solar wind pressure but not by a shock. There is some evidence that magnetic merging occurred at a HCS crossing in the October case at a dip in field intensity, having the appearance of a magnetic hole. The similarities and differences of these events will be pointed out, as well as the reasons for their geoeffectiveness.

W3-04

SOLAR SOURCES OF GEOACTIVITY DURING SEPTEMBER – OCTOBER 1999

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I review the solar sources that appear to have been related to the extended periods of southward magnetic field and high speed in the solar wind at 1 AU which caused the magnetic storms events during the extended Space Weather Month Campaign: September – October 1999. At Earth this period was dominated by two major storms, on Sept. 22 – 23, peak $Dst = -164$ nT, and Oct. 22, peak $Dst = -231$ nT. At the Sun both of these events were associated with filament eruption/coronal arcade events, dimming regions and possible coronal waves. The first event appeared as a faint, but full halo coronal mass ejection (CME) in the SOHO LASCO C2 coronagraph on Sept. 20, 0606 UT following an erupting filament in the south-central part of the disk. The second event was a partial halo (210 deg.) CME first visible in C2 on Oct. 18, 0006 UT; it followed a filament eruption on the southeast disk. Neither of these events were associated with energetic flares. There were two earlier intervals in September having moderate ($Dst > -50$ nT) storm levels. Two storms on Sept. 12 – 14 were associated with an interplanetary (IP) shock and a sector boundary crossing on Sept. 12, but no obvious solar events. The second interval, during the ISR world days, also had two storms on Sept. 15 and 16. These followed IP shocks and ejecta that may have been related to two partial halo CMEs and moderate flares from near Sun center on Sept. 13.

W3-05

OVERVIEW OF GEOEFFECTIVENESS DURING THE SCOSTEP S-RAMP CAMPAIGN INTERVALS

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Space Weather month was a campaign interval during September 1999, coordinated in order to study space weather events from their solar origins to their impacts at Earth. In this talk we will present a high-level overview of the magnetospheric effects during the September 1999 Space Weather Campaign period. We will investigate the transfer of energy from the solar wind into the Earth's magnetosphere and ionosphere during three geoeffective periods. Interplanetary signatures – shocks, ejecta and southward interplanetary magnetic field – were observed during each interval and magnetospheric storms were triggered. These three events will be compared to previously identified coronal mass ejection driven storms which occurred during 1997 – 1999.

Details of the S-RAMP campaign can be found at the following web site:- http://aoss.engin.umich.edu/intl_space_weather/sr

W3-06

A REVIEW OF THE GLOBAL IONOSPHERE DURING SPACE WEATHER MONTH, SEPTEMBER 1999

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During Space Weather Month, September 1999, there were no major ionospheric storms. Much of the month, ionospheric conditions at locations from low to high latitudes were close to average. However, all sites, during the month, showed periods when the behaviour departed from average. In some cases, nighttime electron densities were lower than usual, in others there were daytime enhancements in electron densities. The ionospheric conditions are reviewed and where possible, using global observations, an integrated picture of any small changes is developed. Periods of special interest will be identified for further studies. In addition, the period in late October, when a large *Dst* excursion was observed, is also surveyed and contrasted with the September 22 period, the most disturbed period during Space Weather Month.

W3-07

A REVIEW OF FORECASTS MADE DURING SPACE WEATHER MONTH, SEPTEMBER, 1999

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The International Space Environment Service (ISES) is made up of Regional Warning Centres (RWCs) which make forecasts of the space environment for each day. These forecasts are major products of the RWCs and are used as the basis for their own services to users. As a special service during Space Weather Month, ISES established a web page that combined the forecasts and reports of several RWCs in a common format on a single Web page (www.ips.gov.au/asfc/sramp) at IPS Radio and Space Services. This paper reviews the process by which this page was established, summarises the success and failure of the predictions made by the RWCs, and discusses how the system can lead to a global forecast system with contributions from all RWCs. Such a global approach can result in more complete space weather information system. The simple system established for Space Weather Month is a start towards this global forecast approach.

W3-08

OVERVIEW OF EFFECTS DURING SPACE WEATHER MONTH

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We present an overview of the effects on technological systems that were produced during the intervals of geomagnetic activity that occurred during the space weather study interval in September and October 1999. Large fluctuations of geomagnetically induced currents (GIC) were observed in power systems and pipelines in Scandinavia and North America, and we examine exactly what features of the disturbance led to the largest GIC. We also investigate the effects on satellites of the increased energies of radiation belt electrons produced during these disturbances. Effects to other systems, such as radio communications and the GPS system will also be reported. Analysis of the collected observations will be used to identify the important issues that need to be considered to improve our understanding of space weather effects on technology.

W3-P01

ANALYSIS OF RESULTS OF MULTIDISCIPLINARY OBSERVATIONS MADE ONBOARD US ICE DRIFTING VESSEL SHEBA DURING APRIL–MAY 1998

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A wide spectrum of scientific observations (primarily of hydrometeorological character) was performed onboard US ice drifting vessel SHEBA during her cruise in Beaufort Sea and Chukchi Sea in spring of 1998. One of the authors (APM) was a participant of this expedition and he made observations of the total ozone concentration with daily measurements at every 3 hours. Geophysically speaking, the period of April/May, 1998 was very active. A sequence of the solar proton events (SPE) was started on April 20 and continued until May 3. Simultaneous intensive precipitation of relativistic electron fluxes ($E > 2$ MeV) was registered A notable Forbush-effect was registered by the ground-based neutron monitors. Therefore an unique opportunity appeared to study impact of the solar proton and relativistic electron fluxes on the polar atmosphere at different altitudes. In this paper the following problems are considered. 1) We tried to separate effects of the solar proton fluxes and relativistic electron fluxes on the ozone density in the polar atmosphere taking into account simultaneous impact of both kinds of the precipitating particles on the atmosphere. 2) Using simultaneous measurements of vertical distribution of atmospheric temperature by baloon soundings and ozone density we tried to evaluate effects of the solar wind disturbances on these both parameters. 3) During this campaign SHEBA was located in the polar cap area (for short time) and in the auroral oval. It was worthwhile to inspect any possible difference in behaviour of the polar atmosphere in both situations.

W3-P02

GROUND-BASED OBSERVATIONS AT ZHONGSHAN STATION, ANTARCTICA DURING THE EARLY MAY, 1998 EVENTS

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Zhongshan Station (69.4 S, 76.4 E geographic) is located at invariant latitude 74.5 S. Near magnetic local noon, Zhongshan is frequently under the ionospheric projection of the high latitude magnetospheric cusp region. This paper presents multiple, simultaneous observations at Zhongshan Station for the interval of May $1-7$, 1998, to demonstrate the responses of the high-latitude ionosphere to the major magnetic storm which began on May 2. During the storm onset the ionosphere F2 layer abruptly increased in altitude started at about 0543 UT, the geomagnetic H-component started negative deviation at 0548 UT, the strong ULF wave activity started at about 0620 UT, and both large isolated riometer absorption and large negative deviation of the geomagnetic H-component occurred at about 0639 UT. There was a time lag of about 1.5 hours between the storm onset and the IMF southward turning measured by the WIND satellite. This time delay can be ascribed to the processes which establish the electric fields, particle convection and subsequent energization within the near-earth plasma sheet. The high-latitude ionosphere was highly disturbed, as shown by large deviations of the geomagnetic H-component, large riometer absorption events and strong ULF waves during all phases of the storm. The absorption increased enough to cause the digisonde to be in blackout most of the time. However, the data still showed a substantial decrease of the F2 electron density and oscillations of the F2 later peak height with an amplitude exceeding 200 km.

W3-P03

LARGE-SCALE GEOMAGNETIC EFFECTS OF MAY 4, 1998

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We study large-scale magnetospheric disturbances elicited by the May 4, 1998 high speed stream by modeling the *Dst* and studying records from 5 meridional magnetometer chains covering all local times. The possible solar origins are investigated. The major geoeffects can be neatly separated because the erosion episode ($B_z << 0$) mainly preceded the compression episode. Ring current evolution is followed by the kinetic model of *Jordanova et al.* [1996; 1998], which includes both charge exchange and Coulomb collisions on ring current ions H^+ and O^+ drifting in a Volland-Stern convection electric field. The data show evidence of (a) large enhancements of magnetopause currents; (b) substorm onsets, some of which were triggered; (c) a convection reversal boundary at relatively low latitudes; and (d) what might be omega bands associated with substorm recovery. Station Halley Bay recorded an extraordinary change by 10 % of the ambient magnetic field which we relate to a sharp 5-fold increase in the dynamic pressure.

W3-P04

POWER SYSTEM EFFECTS OF MAY 4, 1998 GEOMAGNETIC DISTURBANCE

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We present observations of the geomagnetically induced currents resulting from the exceptionally high energy transfer into the magnetosphere that occurred over a 3-hour period on May 4, 1998. Other reports have already shown that a combination of corotating streams and magnetic cloud caused a jump in solar wind speed at 0230 UT from 500 km/sec to over 800 km/sec accompanied by a strong interplanetary magnetic field with a large southward component. This produced an intense westward electrojet over North America with a magnetic excursion on the ground between 0400 and 0500 UT that exceeded 1500 nT. We use the ground magnetic data to calculate the geo-electric fields during this time and show that the maximum electric field coincides with the peak GIC variations on power systems in eastern Canada and the northeastern US. The power system response to the GIC included increased harmonic levels, voltage drops, and tripping of capacitor banks.

W3-P05

LARGE ESF ION DEPLETION EVENT DURING THE APRIL 6 – 7, 2000 MAGNETIC STORM

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During the main phase of the April 6 – 7, 2000 magnetic storm, the ionosphere was lifted upward to a density of about 10^7 ions/cc at 600 km altitude. Shortly after 0130 UT, April 7 at the height of storm main phase, a series of equatorial spred-F (ESF) events on both sides of the local midnight sector were observed by ROCSAT-1 for four consecutive orbits. The longitudinal span of the post-midnight events is about 50 degrees. Imbedded in these series of ESF events, there were two extremely large density dropout wells of 10-degree wide in longitude. This corresponds to a width of 1100 km across the equatorial flux tube. Observations of these ESF events (including the two large density dropouts) in the last three ROCSAT-1 orbits indicated that no usual upward/poleward plasma flow inside the bubbles were observed. The reason could be due to the fact that the dominant large-scale storm-time plasma flow overshadowed the small-scale flow inside the bubbles. Alternatively, the peak of the ionosphere could have been lifted above the orbit of ROCSAT-1 so that no apparent flow were detected in the density dropout wells as was reported in the May 1989 storm event (*Greenspan et al.*, 1991). By calculating the drifted distance of the density dropout well in the two consecutive ROCSAT-1 orbits, we deduced that the storm-time westward flow at the post-midnight ionosphere is about 180 m/s. This westward flow will also be checked from the onboard Drift Meter and RPA data.

W3-P06

ESTIMATE OF GLOBAL ENERGY DEPOSITION DURING THE MAY 1998 STORM

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Through solar wind-magnetosphere interaction, solar wind energy is deposited into the Earth's magnetosphere as auroral precipitation and Joule heating in the high-latitude ionosphere, as ring current energization in the inner magnetosphere, and as plasma sheet particle heating and plasmoid ejection in the magnetotail. A comprehensive set of data collected from satellites and ground based instruments allows us to examine quantitatively the energy deposition associated with the first three major magnetospheric sinks during the May 2 – 5, 1998 storm. It is found that Joule heating rate reached about 2000 GW, auroral precipitation went up to 240 GW, and the peak ring current energy injection rate was about 1400 GW at the storm main phase when *Dst* was about −250 nT. The energy coupling efficiency between the solar wind and the magnetosphere will also be examined.

W3-P07

IMPACT OF THE MAY 2 – 5, 1998 GEOMAGNETIC STORM ACTIVITY ON THE DSCS III B-7 SPACECRAFT FRAME POTENTIAL

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Observations of frame charging of the DSCS III B-7 geosynchronous satellite relative to the background plasma during the May 2 – 5, 1998 period of intense geomagnetic activity are presented. During this time, the ring current index *Dst* reached negative levels down to −100, −216, and −138 nT on the 2nd, 4th, and 5th of May, respectively, indicating a sequential chain of three significant storms occurring in rapid succession. The DSCS satellite experienced several hours of significant levels of negative frame charging on the 2nd and 5th of May, but it did not charge on May 4th, the day with the most extreme levels of geomagnetic activity within the study period. On this day, the satellite measured fluxes of electrons in the 20 – 50 keV energy bin (the electrons responsible for frame charging) that were moderate in amount, yet large enough such that frame charging should have been observed. It is postulated that the spacecraft was neutralized by an unusual charged particle environment surrounding the spacecraft that was particularly conducive to providing a source of positive current to the spacecraft surface. Two aspects of the environment modification that would satisfy this requirement include an increase in energetic ions and injection of lower-energy superthermal electrons, both of which are known to mitigate spacecraft surface charging. The POLAR satellite recorded enhancements of the energetic ion fluxes during the critical time period on May 4th when the large count of charging electrons should have led to frame charging, suggesting that these ions provided a significant source of positive current that served as a neutralizing factor. The behavior of spacecraft frame potentials during extreme storm activity accompanied by these unusual features of magnetospheric modification has implications for statistical studies that nominally show a general correlation between levels of geomagnetic activity and spacecraft frame charging at geosynchronous orbits.

W3-P08

COUPLING OF ULF WAVES/TRANSIENTS AT THE DAYSIDE CUSP AND THE NIGHTTIME CONJUGATE AURORAL REGIONS AS OBSERVED AT CPMN-GREENLAND-ANTARCTIC FACILITY

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The exact role of ULF turbulence in the growth and expansion phases of substorms, as well as the physical mechanism of a substorm itself, have not yet been firmly established. Dayside magnetic activity is a potentially important factor in substorm prediction, *i.e.*, for space weather forecasting, because high-latitude dayside ULF activity could be an indicator of an enhanced rate of turbulent energy supply into the magnetosphere during the growth phase of a substorm. The spatial-temporal distributions of different types of ULF waves and the transient features in global ionospheric electrodynamics are studied with the dataset from three magnetometer arrays: CPM Network, Greenland Coastal Array and Russian-US Antarctic stations. These arrays provide a unique opportunity to form the conjugate day-night and inter-hemisphere facility for simultaneous monitoring of ULF waves/transients. This facility could be a "backbone" of global world-wide magnetic monitoring system and should be augmented with other high-latitude networks. Emphasis in presented research has been placed on the study of the correspondence between the growth and expansion phases of magnetospheric substorms at the nightside and dynamics of dayside ULF activity at cusp/cleft latitudes in order to better understand the role of ULF waves as a possible substorm precursor.

W3-P09

IMPACT OF THE INTERPLANETARY SHOCK ON ULF WAVE ACTIVITY: A CASE STUDY OF Pc 1 AND IPDP EVENTS BEFORE AND AFTER THE SSC ON SEPEMBER 22, 1999

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We have analysed the short-period geomagnetic pulsations measured by the north-south chain of pulsation magnetometers in Finland in association with the storm sudden commencement recorded on September 22, 1999 at 12.18 UT. We observe that structured Pc 1 pulsations with an abnormal repetition period (about 1000 seconds) were excited before the SSC whereas an IPDP plasma wave event with an unusually high end frequency appears soon after the SSC. It is concluded that the first effect is due to the interaction of the Earth's magnetosphere with the interplanetary foreshock region. The second one, *i.e.* the generation of the IPDP event is likely the result of the inward radial drift of the generation region under the action of intense electric field of the large-scale convection induced by the compression of the magnetosphere during the initial phase of the magnetic storm.

W3-P10

VIEW FROM THE GROUND: 21 – 22 OCTOBER 1999 EVENT

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Starting from the ground results of the solar disturbances that took place during the second half of October 1999, we look back through the sequence of events that occured in the ionosphere, magnetosphere and solar wind to their origin on the Sun. Large geomagnetically induced currents (GIC) were observed on ground systems on October 22, 1999. We present GIC data from power systems and pipelines in the northeastern United States and Canada, and show that they coincided with large fluctuations in the geoelectromagnetic field. Geomagnetic observatory data are used to determine the beginning and the evolution of the ground disturbance and to calculate the electric fields over the affected area. SuperDARN ionospheric convection maps and POLAR auroral images show the changes in the ionospheric characteristics that produced the ground disturbance. ACE data and solar observations show the connection between the observed and modeled fetures on the ground and their solar origin.

W3-P11

LOW ALTITUDE OBSERVATIONS OF ELECTRONS AND PROTONS

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Using the NOAA low orbiting satellites an overview of precipitating electrons and ions during the April–May 1998/September 1999 events will be given.

W3-P12

OBSERVING THE AURORAL ELECTROJET WITH THE ØRSTED SATELLITE DURING THE SEPTEMBER 1999 SPACE WEATHER MONTH

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The high accuracy of the magnetic measurements and good stability of the instruments of the Ørsted satellite make it possible to determine at the altitude of the satellite the small contributions from the horizontal ionospheric currents, for example from the auroral electrojet. A technique has been developed based on the measurements of the absolute value of the magnetic field, which provides for each polar crossing individually (*i.e.* every 50 minutes either North or South) the intensity and distribution of the east-west going ionospheric currents along the orbit. The integrated total intensity of that current for each pass through the auroral oval provides a measure, which is highly correlated with the ground based AE-index. In addition, though, the method provides information on the latitudinal position and extension of the electrojet currents as well as other observed current systems. This poster will present the results of applying this technique to Ørsted data for the whole S-RAMP Space-weather month of September 1999. Orbit by orbit we can follow the large-scale evolution of (mainly) the westward electrojet both in the Northern and Southern hemisphere in the near noon and midnight sectors of the satellite orbit.

W3-P13

SPECTRAL FEATURES OF GEOMAGNETIC DISTURBANCES FOR S-RAMP EVENTS

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The 1-min data of world-wide network of magnetic observatories for the S-RAMP events are collected and spectra were obtained. The data show structured spectra with distinct peaks in $5-15$ minutes as Pi 3 pulsations, in $10-30$ minutes as Ps 6 pulsations, and in $30-60$ minutes as the sequence of substorms (bay trains). The existence of longer periods pulsations are also confirmed. These peaks repeated during severe activity and split spectra on separate bands. The intensity of peaks are varied on the stations in polar cap, auroral zone and middle latitudes but value of peaks are stable in each separate case. The origin of spectra connected with dynamics of current systems in the ionosphere and magnetosphere. We suppose that Pi 3 pulsations connected with irregular wave type processes in the magnetosphere and the outer space, Ps 6 pulsations accompany the westward electrojet and must be in the very close connection with the processes which lead to the origin of substorms itself. The sequence of substorms might arise due to large-scale features of solar wind interaction with magnetosphere. The comparative analysis of satellite data with magnetometer data will lead to search the processes as the large-scale movements of magnetopause, the formation of vortixes on magnetopause and the flapping motion of magnetotail when vortixes propagate along surface of magnetotail. The detailed search of magnetometer spectra lead to more clear understanding of spacial and temporal processes in the outer space.

W3-P14

COMPARISON BETWEEN SIMULATIONS AND OBSERVATIONS ON SEPTEMBER AND OCTOBER 1999 EVENTS

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Substorms/storms events of September 21−23, 1999 in the S-RAMP interval and October 22−24, 1999 are interesting and conspicuous examples to test the simulation model and compare the simulation results with observations. The solar wind and 3 components of the interplanetary magnetic field (IMF) furiously veried for 12−24 UT on September 22 in the ACE observations and the geomagnetic activities enhanced for 20 − 24 UT on the quick look indices of WDC-C2, Kyoto University. The peak position in the energy spectrum of outer radiation belt electrons somewhat shifted from $L = 3.8$ to 3.2, however energetic electrons did not increase in Akebono observation, partly because the IMF kept northward after September 23. There was almost no activity of substorms in that interval. On October 22, the solar wind and 3 components of the IMF again furiously veried and the IMF z-component specially showed very strong negative value of $B_z = -30$ nT for 00 − 02 UT. It triggered a strong geomagnetic storm and had an important effect on energetic electrons in MeV ranges in the outer radiation belt. The peak position in the energy spectrum shifted from $L = 3.8$ to $L = 2.8$ in later time on that day and the flux decreased one order. On 22 − 24, the energetic electrons rapidly recovered and were diffused outward keeping peak position of $L = 3$ in a view of Akebono observation. We are particularly interested in relationship between substorms and storms at 01 UT and 04 UT on 22. We try to simulate the events of September and October, 1999 by using a 3-dimensional global MHD model of interaction between the solar wind and the magnetosphere and the ACE satellite observations as input of simulation. We will discuss associations of particle distribution with magnetospheric configuration depending on each phases of substorms/storms.

W3-P15

RSWI IN SEPTEMBER 1999 SPACE WEATHER MONTH CAMPAIGN

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Russian Space Weather Initiatives took an active part in the September 1999 space weather campaign interval. Different Russian scientific groups presented their experimental data and model results on Web -site http://dec1.npi.msu.su/~dalex/events/iswmc/sept99.htm devoted this interval. Practically any chains of the solar-terrestrial linking are reflected on the site: solar activity, heliospheric conditions, dynamics of the cosmic rays, geomagnetic field and low altitude space radiation. Experimental data and model applications include also the geomagnetic storm period on September 23 − 25 1999. Background conditions and development of the space weather disturbances on September 1999 are presented in the paper.

W3-P16

FIELD-ALIGNED AND IONOSPHERIC CURRENTS AT HIGH LATITUDES DURING THE SEPTEMBER 1999 SPACE WEATHER MONTH

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September 1999 was a magnetically active month featuring several magnetic storms. The DMI Greenland magnetometers recorded variations of the polar electrojet during the storms while the Ørsted satellite observed the magnetic field of field-aligned currents (FACs) on several polar passes. Coincident solar wind (SW) and interplanetary magnetic field (IMF) data were obtained from the ACE spacecraft. Some dayside polebound Ørsted passes followed tracks along the Greenland west coast, closely aligned with the corrected geomagnetic (CGM) noon meridian conjugate to the DMI west coast magnetometer chain. Several passes occured while the Sondrestrom (Greenland) incoherent scatter radar was in operation. The combined data, ground-based magnetograms, Ørsted magnetic field data, and Sondrestrom radar observations, yield a consistent view of the field-aligned/horizontal electrical current system. Inspection of the time evolution of the ionospheric current indicates that the response of the magnetosphere-ionosphere system to changes in the interplanetary medium occurred within a few minutes, at least at the highest latitudes, poleward of the standard auroral oval, but not necessarily in the auroral zone.

W3-P17

AURORAL ZONE HEATING COMPARISONS FOR SEPTEMBER 1999

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We have parameterized Joule heating and particle energy deposition based on Interplanetary Magnetic Field (IMF) magnitude and orientation as well as on the Polar Cap (*PC*) index. Previous work [*Chun et al.*, 1999] has shown that upper atmosphere Joule heating is well correlated with the *PC* index. Using a data-base of more than 13,000 patterns we have created average patterns that can be used as a quick look-up table to show how the heating varies with changing geomagnetic conditions. We will present the time series of these patterns for the entire month and compare the results with estimates of heating from the DMSP spacecraft and with data assimilation via the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) Procedure.

W3-P18

SUPERDARN IONOSPHERIC CONVECTION MAPS FOR SPACE WEATHER MONTHS

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Ionospheric convection maps are derived from SuperDARN velocity measurements for the Space Weather Months of 1998 and 1999. Convection maps, or the equivalent electrostatic potential maps, are available at 2-min resolution for the April/May 1998, September 1999, and October 1999 events. Periods of interest during these events are investigated using an established fitting technique developed at the Johns Hopkins University Applied Physics Laboratory (JHU/APL). Improvements to the APL fitting technique and a significant increase in radar coverage demonstrate the potential value to space weather of high latitude convection maps determined from SuperDARN measurements.

W3-P19

MULTI-POINT OBSERVATIONS OF THE MAGNETOSPHERIC PLASMA DENSITY DURING MAGNETIC STORM EVENTS

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This study presents the observations of magnetospheric plasma density from both spacecraft data and the estimates inferred by ground magnetometer data to understand how the magnetosphere varies under the influence of strong magnetic storms. For ground observations, the gradient method of magnetic pulsations is a proven technique that can find the eigenfrequencies of magnetospheric field lines, and the information of eigenfrequencies can be used to estimate the plasma mass density of the magnetosphere. The equatorial plasma densities at $L = 2.1$, 4.8, 6.0, 7.4 and 9.1 are calculated from the magnetometer data of the IGPP/LANL array and the CANOPUS array. We find that a strong depletion occurred in the plasmasphere at $L = 2.1$ during the September 1998 magnetic storm, and it took $4 - 5$ days to recover. In contrast the density was enhanced at mid and high latitudes $L = 4.3 - 9.1$. The whistlers in the VLF band observed at Palmer, Antartica ($L = 2.4$), also found a similar decrease of the inferred electron densities from the method of curve fitting. These inferred densities from ground measurements are compared with in situ spacecraft data. The low-energy (< 100 eV/e) ion density observed by the magnetospheric plasma analyzers (MPA) on board four Los Alamos satellites in geosynchronous orbit is derived from E/q measurements under the assumption that the ions are protons; for heavier ions, the true density would be higher than this estimate by a factor of the square root of the mass. Under the proton assumption, the resulting densities are found to be $10 - 50$ % of the plasma mass density inferred from ground magnetometer data. In addition, we analyze the TIMAS data of the

Polar satellite to understand the variation of warm plasma in the magnetosphere during this large magnetic storm. The variation of magnetospheric density during the September 1999 magnetic storm event will also be discussed.

W3-P20

HF RADAR SIGNATURE OF GEOMAGNETIC STORMS DURING THE S-RAMP CAMPAIGN PERIOD

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During the S-RAMP campaign period, there were a few geomagnetic storms observed, with the major ones during May 2 – 4, 1998 and during September 22 – 24, 1999. Syowa East and South radars were continuously monitoring the high-latitude ionosphere in the southern hemisphere. During the storms, both radars observed intensification of the convective flows. Besides that, they observed ionospheric echoes with high Doppler velocity (> 500 m/s) and very low (< 60 m/s) Doppler spectral width, around the negative peak of the *Dst* index. These unusual echoes indicate that the flows were very stable, and also the structures of decameter-scale ionospheric irregularities, which are responsible for the HF wave backscattering, were very stable both in space and time. This signature is consistent with the statistical analysis of the Syowa East HF radar echoes during geomagnetic storms. Possible mechanisms for generating these echoes will be discussed.

W3-P21

COSMIC RAY INTENSITY BAHAVIOR DURING SEPTEMBER 1999

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Variation of cosmic ray intensity during the September 1999 interval is analysed using available data of the ground-based neutron monitor network, the solar vind velocity and the interplanetary magnetic field data from IMP satellite. Different techniques are used: global survey method and spectral analysis of the data. The behavior of about 10 GV cosmic ray density near the Earth and components of anistropy vector is presented.

W3-P22

GIC EVENTS DURING THE SPACE WEATHER MONTH OF SEPTEMBER 1999

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During the Space Weather month of September 1999, intense geomagnetic activity occurred around Sep 12 – 16 and Sep 21 – 23, resulting in geomagnetically induced current (GIC) events measured in power systems in Canada and the US. The solar origins of both events appear to be different, with the former possibly due to coronal holes and the latter likely due to coronal mass ejections associated with disappearing filaments. As such, the interplanetary signatures of both events seem to be different. We trace the GIC events from their solar orgin, through the interplanetary medium, to the measured magnetic and calculated electric fluctuations on the ground and their eventual occurrence on the power systems.

W3-P23

PHASE FLUCTUATIONS OF GPS SIGNALS IN HIGH LATITUDE IONOSPHERE DURING SEPTEMBER 1999 DISTURBANCE

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The GPS measurements of North European network have been used for study the development of ionospheric irregularities during storm. The permanent GPS observations carried out on IGS network provide the measurements of total electron content every 30 sec. This rate of sampling data allow to detect the irregularities with scale sizes more than 30 km. The distinct network of GPS stations and multi-path observations simultaneously of 6 – 8 satellites provided for the high spatial resolution in occurrence of the phase fluctuation. For analysis of rate of TEC we use the data on the variations of phase along the subionospheric trajectories of the single satellites which were observed simultaneously from many sites. During the magnetic active period (12 – 16 September 1999) the phase fluctuations registered in full period at geomagnetic latitudes 60 – 70°N. The maximal occurrence of the fluctuations are observed near the magnetic midnight. The amplitude of fluctuations are weakly depended on the elevations of the satellite. The strong fluctuations can be observed over the full satellite passes. In some time the patch-like perturbations we also found. Near magnetic midnight the developments of phase fluctuations extended to the lower latitudes (up to 55°N). At the lower latitudes the irregularities with more scale sizes prevail relative to high latitude irregularities.

AUTHOR INDEX

Bold designates the first author.

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Timetable of The First S-RAMP Conference

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Mon Oct 2	8:30-	*Registration (Royton Sapporo)*						
	9:30-10:50	S16: Ionosphere-Thermosphere-Mesopause Coupling	S3: CMEs and Coronal Holes	S6: Comparison of Observations and Simulations of Global Magnetospheric Structure	S9: Energetic Particle Dynamics in the Inner Magnetosphere	S14: Wave-Particle Interactions at Shocks and Boundary Layers	S7: Tail Plasma Flows and Ionospheric Consequences	
	Break							
	11:10-12:30							
	Lunch							
	14:00-15:20	S16: Ionosphere-Thermosphere-Mesopause Coupling	S3: CMEs and Coronal Holes	S6: Comparison of Observations and Simulations of Global Magnetospheric Structure	S9: Energetic Particle Dynamics in the Inner Magnetosphere	S14: Wave-Particle Interactions at Shocks and Boundary Layers	S7: Tail Plasma Flows and Ionospheric Consequences	
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	15:40-17:20							
	18:00-20:00	*Welcoming Party*						
Tue Oct 3	8:30-9:30							Tutorial 1
	9:30-10:50	S17: Middle Atmosphere Including Response to Forcing From Above and Below	S4: Interplanetary Disturbances	S1: Space Weather: Prediction Techniques	S13: Aurora Dynamics and Plasma Wave Emissions	S10: Magnetic Reconnection: Theory and Simulations	S5: Solar Wind Effects on Ionospheric Convection	S16: Ionosphere-Thermosphere-Mesopause Coupling
	Break							
	11:10-12:30							
	Lunch							
	14:00-15:20	S17: Middle Atmosphere Including Response to Forcing From Above and Below	S4: Interplanetary Disturbances	S1: Space Weather: Prediction Techniques	S13: Aurora Dynamics and Plasma Wave Emissions	S10: Magnetic Reconnection: Theory and Simulations	S5: Solar Wind Effects on Ionospheric Convection	S16: Ionosphere-Thermosphere-Mesopause Coupling
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	15:40-17:20							
	17:00-21:30	W1: Space Weather Observation in Future (17:00-19:30)		W2: Satellite Anomalies (17:00-19:00)	PURAES Meeting (17:00-19:00)	LRPC Open Meeting. (19:30-21:30)	W3: April-May 1998 / September 1999 Events (17:20-21:00)	
Wed Oct 4	8:30-12:00	Poster Session: S1, S3, S4, S6, S7, S9, S13, S14, S16 (Sapporo Media Park)						
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	13:30-18:00	*Excursion*						
	18:00-20:00	*Conference Dinner*						
Thu Oct 5	8:30-9:30							Tutorial 2
	9:30-12:30	Poster Session: S2, S5, S8, S10, S11, S12, S15, S17, S18, S19, W1,W2 (Sapporo Media Park)						
	Lunch							
	14:00-15:20	S17: Middle Atmosphere Including Response to Forcing From Above and Below	S8: Storm-Time Ring Current	S2: Space Weather	S15: Kinetic Theory and Simulations of Micro and Meso Scale Phenomena	S11: Cross-Scale Coupling: Observations and Theories	S5: Solar Wind Effects on Ionospheric Convection	S12: ULF and VLF Waves in the Magnetosphere
	Break							
	15:40-17:20							
	17:00-21:30	W1: Space Weather Observation in Future (17:00-19:00)		W2: Satellite Anomalies (17:00-19:00)			W3: April-May 1998 / September 1999 Events (17:20-21:00)	
Fri Oct 6	8:30-9:30							Tutorial 3
	9:30-10:50	S18: Solar Variability Effects Upon the Lower Atmosphere and Climate	S8: Storm-Time Ring Current	S2: Space Weather	S19: Active Experiments and Spacecraft-Environment Interactions	S11: Cross-Scale Coupling: Observations and Theories	S12: ULF and VLF Waves in the Magnetosphere	
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Tutorial 1: Solar-Terrestrial Physics - Past Achievements and Future Opportunities / Daniel N. Baker

Tutorial 2: Global Circulation of the Middle Atmosphere / Isamu Hirota

Tutorial 3: Sun-Earth Coupling and Possible Effects on Earth's Climate / Eigil Friis-Christensen